ARITHMETIC
of
PHARMACY

STEVENS

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ARITHMETIC OF PHARMACY

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BY

A. B. STEVENS, Ph.D., Ph.C.
College of Pharmacy, University of Michigan

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PREFACE TO THE FOURTH EDITION

As in previous editions the use of higher mathematical terms has been avoided, and the analyses made as simple as possible that they may better serve the needs of the average student. Some subjects have been treated in a manner that may seem unnecessarily simple, but these may be omitted by the more advanced student.

The book was originally written as an aid to students not having had the advantages of a college education, and answers were given to nearly all the problems. Since then it has come into general use as a text-book. Therefore, in deference to many teachers who use it, most of the answers have been omitted. The rules have also been omitted, with the hope that students will become more independent thinkers, instead of relying on the memory for certain rules.

The specific gravity and other data necessary for calculation of problems are usually given. Otherwise the student is referred to the last revision of the Pharmacopœia. Slight differences in results may be obtained due to the extent to which the decimals have been carried out. This is especially true in problems where the equivalents of weights and measures have been used.

Saturation Tables have been added. These tables were first prepared by H. B. and C. W. Parsons for the U. S. P. VI, and were retained in U. S. P. VII and VIII. Dr. A. B. Lyons and the author revised them for the U. S. P. IX, but later the Committee decided to drop them. The author considered these tables too valuable to be lost and has therefore brought them up to date. Every pharmacist should become familiar with these tables, as, by their use many preparations may be extemporaneously made, and often, time and money saved. They contain answers to 758 problems, from which teachers may select problems for special exercises.

A. B. STEVENS.

Ann Arbor, Michigan.

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ARITHMETIC OF PHARMACY

TABLES—WEIGHTS AND MEASURES

METRIC SYSTEM

The units of the metric system are Meter, Liter, Gram. The denominations above these units are expressed by adding the Greek prefixes Deka, 10; Hecto, 100; Kilo, 1000. The subdivisions are expressed by adding the Latin prefixes Deci, 0.1; Centi, 0.01; Milli, 0.001. The abbreviations of the units and multiples should begin with capitals, and those of the subdivisions with small letters.

Linear Measure		Volume		Weight		
Kilometer,	Km.	Kiloliter,	Kl.	Kilogram,	Kg.	1000.0
Hectometer,	Hm.	Hectoliter,	Hl.	Hectogram,	Hg.	100.0
Dekameter,	Dm.	Dekaliter,	Dl.	Dekagram,	Dg.	10.0
Meter,	M.	Liter,	L.	Gram,	Gm.	1.0
Decimeter,	dm.	Deciliter,	dl.	Decigram,	dg.	0.1
Centimeter,	cm.	Centiliter,	cl.	Centigram,	cg.	0.01
Millimeter,	mm.	Milliliter,	ml.	Milligram,	mg.	0.001

The prefixes, Deka, Hecto, Deci and Centi are seldom used, their equivalents being expressed by use of multiples and subdivisions of their respective units, in the same manner that our decimal currency is expressed. It has been customary to use cubic centimeter, Cc., in place of the milliliter, but the U. S. P. and N. F. now use the more convenient term "mil."

A mil of distilled water when weighed in vacuo at 4° C. weighs 1 gram; when weighed in air at 15.6° C. it weighs 0.998 gram.

APOTHECARIES' WEIGHT

1 Pound, lb. = 12 Ounces, = 5760 Grains, gr.
1 Ounce, ℥ = 8 Drams, = 480 Grains, gr.
1 Dram, ʒ = 3 Scruples, = 60 Grains, gr.
1 Scruple, ℈ = 20 Grains, gr.

The Apothecaries' ounce and grain are of the same value as the now obsolete English Troy ounce and grain. The term "Troy Weight" is frequently used when Apothecaries' weight is intended.

APOTHECARIES' FLUID MEASURE

Wine Measure

1 Gallon, Cong. = 8 Pints, = 128 Fluidounces.
1 Pint, O. = 16 Fluidounces.
1 Fluidounce, f ℥ = 8 Fluidrams, = 480 Minims, ♏.
1 Fluidram, f ʒ = 60 Minims, ♏.

The Apothecaries' Fluidounce of distilled water weighs, in vacuo, at 4° C. (39.2° F.), 456.392 grains. It weighs in air, at 15.6° C. (60° F.), 455.7 grains.

AVOIRDUPOIS WEIGHTS

1 Pound, lb. = 16 Ounces, = 7000 Grains, gr.
1 Ounce, oz. = 437.5 Grains, gr.

IMPERIAL MEASURE

1 Gallon, C. = 8 Pints, = 160 Fluidounces.
1 Pint, O. = 20 Fluidounces.
1 Fluidounce, fl. oz. = 8 Fluidrams, fl. dr. = 480 Minims, ♏.

The Imperial gallon contains 10 Avoirdupois pounds of distilled water at 15.6° C. The fluidounce therefore contains 437.5 grains.

The Imperial fluidounce and the Apothecaries' fluidounce contain the same number of drams, and the same number of minims, but they differ in weight. The Imperial minim weighs 0.9114 of a grain and the Avoirdupois minim weighs 0.9493 of a grain.

APPROXIMATE MEASURES

One tumblerful equals about 8 fluidounces, or 240 Mils.
One teacupful equals about 4 fluidounces, or 120 Mils.
One wineglassful equals about 2 fluidounces, or 60 Mils.
One tablespoonful equals about 4 fluidrams, or 16 Mils.
One dessertspoonful equals about 2 fluidrams, or 8 Mils.
One teaspoonful equals about 1 fluidram, or 4 Mils.

One drop is usually considered equal to one minim; but it varies in size from three-fourths of a drop to four drops in one minim.

APPROXIMATE EQUIVALENTS

The following equivalents are not exact, but are sufficiently accurate for all practical purposes:

1 Gram equals 15.432 Grains.
1 “ “ 0.035 Avoirdupois Ounce.
1 “ “ 0.032 Apothecaries' Ounce.
1 Mil equals 16.23 Apothecaries' Minims.
1 “ “ 16.9 Imperial Minims.
1 “ “ 0.0338 Apothecaries' Fluidounce.
1 “ “ 0.035 Imperial Ounce.
1 Grain equals 64.8 Milligrams.
1 “ “ 1.053 Minims.
1 “ “ 1.097 Imperial Minims.
1 Meter = 39.37 Inches.
1 Apothecaries' Ounce equals 31.1 Grams.
1 “ “ “ 1.097 Avoirdupois Ounces.
1 “ “ “ 1.053 Fluidounces.
1 Avoirdupois Ounce equals 28.35 Grams.
1 “ “ “ 0.911 Apothecaries' Ounce.

1 Avoirdupois Ounce equals 0.961 Fluidounce.
1 “ “ “ 1 Imperial Fluidounce.
1 Apothecaries’ Minim equals 0.9493 Grain.
1 “ “ “ 1.04 Imperial Minims.
1 “ “ “ 0.0613 Mil.
1 Imperial Minim equals 0.9114 Grain.
1 “ “ “ 0.96 Apothecaries’ Minim.
1 “ “ “ 0.059 Mil.
1 Imperial Fluidounce equals 28.35 Mils.
1 Imperial Fluidounce equals 0.96 Apothecaries’ Fluidounce.
1 Apothecaries’ Fluidounce equals 29.57 Mils.
1 “ “ “ 1.04 Avoirdupois Ounces.
1 “ “ “ 0.95 Apothecaries’ Ounce.
1 “ “ “ 1.04 Imperial Fluidounces.

1.—ADDITION, SUBTRACTION, MULTIPLICATION, AND DIVISION OF WEIGHTS AND MEASURES

Abstract numbers increase and decrease in a tenfold ratio, while with compound numbers the scale varies with each denomination.

1.—*Example.* Add 4 pounds, 6 ounces, 5 drams, and 2 pounds, 8 ounces, and 3 drams (Apothecaries’).

4 lb.	6 oz.	5 dr.
2 “	8 “	3 “
7 “	3 “	

The sum of the first term is 8 dr. or 1 oz., which added to the next higher denomination makes 15 oz. or 1 lb. 3 oz. 1 lb. added to the next higher denomination makes 7 lb.

The operation may also be performed by reducing the terms to the same denomination and proceeding as in simple numbers, as follows:—

4 lb. = 4 × 12 × 8 = 384 dr.
6 oz. = 6 × 8 = 48 "
2 lb. = 2 × 12 × 8 = 192 "
8 oz. = 8 × 8 = 64 "
5 + 3 = 8 "
696 " = 7 lb. 3 oz.

2.—Add the following Apothecaries' weights:

5 lb.	4 ℥.	3 ʒ.	2 ℈	12 gr.
4 "	6 "	5 "	1 "	16 "
3 "	10 "	6 "	2 "	18 "
13 "	10 "	0 "	1 "	6 "

3.—Add the following Avoirdupois weights:

8 lb.	4 oz.	75 gr.
2 "	12 "	150 "
3 "	8 "	320 "
14 "	9 "	107.5 "

PROBLEMS

4.—What is the weight of a mixture containing 4 ounces, 5 drams, 20 grains, 8 ounces, 410 grains, 7 drams and 50 grains?

Ans. 1 lb. 2 oz. 4 dr.

5.—What is the weight of compound powder of liquorice formed by mixing the following:—Senna 6 ounces; glycyrrhiza 7 ounces, 6 drams, 40 grains; sulphur 2 ounces, 5 drams, 8 grains; oil of fennel 1 dram, 2 grains; and sugar 16 ounces, 5 drams, 8 grains?

6.—If you have 1 pound, 6 ounces and 4 drams of rhubarb and dispense 4 ounces and 2 drams at one time, and 3 ounces 5 drams and 50 grains at another time, how much will remain?

7.—If you purchase a gallon of alcohol and sell at different times 1 ounce, ½ pint, 2½ ounces, 6 ounces, 2 pints, 4 ounces and 6 drams, how much will remain?

8.—What is the cost of 12 bars of soap at 30 cents a pound if each bar weighs 5 pounds and 6 ounces?

9.—Divide 9 gallons, 8 pints and 10 ounces into 5 equal quantities.

10.—If a gallon mixture requires 1 pound, 4 ounces and 6 drams of drug, how many gallons of mixture can be made from 12 lbs. 6 ounces and 6 drams of the drug?

2.—TO DETERMINE QUANTITIES USED IN MANUFACTURING

1.—*Example.*—How many grams of each ingredient are required in the manufacture of 35 grams of Compound Chalk Powder? The U. S. P. gives the following proportions:

Prepared Chalk	30 Gm.
Acacia	20 Gm.
Sugar	50 Gm.

To make 100 Gm.

The quantity to be made, 35 grams, is 35–100 of 100 grams, the amount of the formula. Hence we must take 35–100 of the amount given for each ingredient, and we have as follows: Prepared chalk 10.5 grams, acacia 7 grams, and sugar 17.5 grams.

PROBLEMS

How much of each ingredient must be used in the manufacture of the following pharmacopœial preparations:

2.—To make 120 Compound Cathartic Pills?

Ans. Comp. ext. colocynth 9.6 Gm., mild mercurous chloride 7.2 Gm., resin of jalap 2.4 Gm., gamboge 1.8 Gm.

3.—To make 300 grams of Comp. Powder of Glycyrrhiza?

Ans. Senna 54 Gm., liquorice 70.8 Gm., sulphur 24 Gm., oil of fennel 1.2 Gm., sugar 150 Gm.

4.—To make 1250 mils of Compound Spirit of Orange?

5.—To make 4.5 liters of Aromatic Elixir?

6.—If you wish to use 11 grams of mercury in the manufacture of Mass of Mercury, how much of the other constituents must be used?

Note.—Proceed as above, except that the quantity of mercury to be used is divided by the quantity of mercury given in the formula. The quantities of the other ingredients are multiplied by this quotient.

Ans. Glycyrrhiza 3.33; althæa 5.00; glycerin 3; honey of rose, 11.00; and Oleate of Mercury 0.33 gram.

7.—How many grams of opium and sugar of milk must be mixed with 25 grams of ipecac to make Dover's Powder?

8.—What quantity of each ingredient is required to compound the following prescription:

			Ans.
℞	Quininæ sulphatis	gr. ij	240 gr.
	Ferri reducti	gr. j	120 gr.
	Acidi arsenosi	gr. 1/40	3 gr.
	Strychninæ sulphatis	gr. 1/60	2 gr.
	Pulveris ipecacuanhæ	gr. 1/8	15 gr.

For one pill. Make 120 such pills.

9.—What is the dose of each ingredient in the following prescriptions?

			Ans.
℞	Sodii bromidi	gr. clx	5 gr.
	Potassii bromidi	gr. lxiv	2 gr.
	Aquæ destillatæ	fl. oz. iv	

Sig. Teaspoonful at bed time.

℞	Extracti colocynthidis	gr. iv
	Aloes	gr. xlviij
	Resinæ scammonii	gr. xxxvj
	Olei caryophylli	gr. vj

Divide into 24 pills.

℞	Strychninæ nitratis	gr. ij
	Liquoris acidi arsenosi	fl. dr. ij
	Aquæ	q. s. ad fl. oz. iij

S. Teaspoonful three times a day.

10.—A pharmacist having a call for 1/25 of a grain of atropine, took half of a 1/50 grain tablet. How much should he have taken?

3.—TO CHANGE WEIGHTS AND MEASURES FROM ONE SYSTEM TO THOSE OF ANOTHER

Troy, Apothecaries' and Avoirdupois weights, Wine and Imperial measures may be changed from one to the other as follows:

1.—*Example.*—Convert 10 ounces and 2 drams Apothecaries' weight into Avoirdupois weight.

Since there are 480 grains in 1 Apothecaries' ounce, there are 4800 grains in 10 ounces. In 2 drams there are

120 grains. 4800 gr. + 120 gr. = 4920 gr., and 4920 gr. ÷ 437.5 (the number of grains in an Avoirdupois ounce) = 11 Avoirdupois ounces and 107.5 grains.

PROBLEMS

2.—Change 10.5 Apothecaries' ounces to fluidounces.

$$\frac{480 \times 10.5}{455.7} = 11 \text{ oz., } 28.7 \text{ Min.}$$

3.—Change 5 pints Wine measure to Imperial measure.

$$\frac{5 \times 16 \times 455.7}{20 \times 437.5} = 83.325 \text{ oz. or 4 pints, 3 ounces, 2 dr., and 36 Min.}$$

4.—Change 5 pounds, 8 ounces Avoirdupois to Apothecaries' weight.

5.—Change 34 ounces, Apothecaries' weight, to Avoirdupois weight.

6.—Convert 1 gallon Wine measure into Imperial measure. ✓

7.—Convert 4 Imperial pints into Wine measure.

8.—Change 5 Avoirdupois pounds to Wine measure.

9.—Change 60 Apothecary ounces into Wine measure.

10.—Change 10 Wine gallons into Avoirdupois weights.

4.—TO CHANGE WEIGHTS AND MEASURES BY THE USE OF EQUIVALENTS FROM ONE SYSTEM TO THOSE OF ANOTHER

(See Approximate Equivalents, Page 3.)

1.—*Example.*—Change 10.5 Apothecaries' ounces to Avoirdupois ounces.

The equivalent of one Apothecaries' ounce is 1.097 Avoirdupois ounces. Hence 10.5 × 1.097 = 11.518 or nearly 11½ Avoirdupois ounces.

The results obtained by the use of equivalents are not quite as accurate as by the preceding method, but are sufficiently accurate for practical purposes. Compare the answer to the following problem with that obtained when working the same problem by the other method; No. 3, page 7.

PROBLEMS

2.—Change 5 Wine pints to Imperial measure.

5 × 16 × 1.04 = 83.2 oz. or 4 pts., 3 oz., 1 dr., 36 min.

3.—Convert 20 fluidounces into mils.

Ans. 591.4 mils.

4.—Convert 5000 mils into fluidounces.

Ans. 169 fluidounces.

5.—Change 800 grams to Avoirdupois weight.

6.—Convert 12 Avoirdupois ounces into grams.

7.—Convert 650 grams into Apothecaries' weight.

8.—Convert 7.5 Apothecaries' ounces into grams.

9.—What is the volume of 10 Avoirdupois pounds of water?

10.—What is the avoirdupois weight of a gallon of water?

11.—How many mils are there in a gallon of water?

12.—What is the cost of 12 2-grain powders of codeine sulphate, when one ounce costs $5.30?

13.—The British Pharmacopœia formula for Syrup is: "Refined sugar, 5 pounds; boiling distilled water, 2 pints. Heat until dissolved, and add boiling distilled water to 7.5 pounds." Change the quantities to Apothecaries' weight and Wine measure.

14.—Change the following to Apothecaries' weight and Wine measure.

Belladonna Liniment

Camphor	50 Gm.
Fl. Ext. Belladonna .... to make	1000 Mils

Ans. Camphor 771.6 gr., fl. ext. belladonna 33 oz. 6 dr. 24 min.

15.—Change the following formula for soap liniment to Imperial weights and measures:

		Ans.
Soap	60 Gm.	2 oz. 50.9 gr.
Camphor	45 Gm.	1 oz. 251.56 gr.
Oil Rosemary	10 Mils	2 dr. 48 min.
Alcohol	700 Mils	25 oz. 3 dr.
Water ....to make	1000 Mils	35 oz.

16.—Change the following prescriptions to the Metric system:

℞ Acetanilidi	gr. xxxvj
Potassii bromidi	gr. xxiv
Caffeinæ citrat.	gr. xij

Divide in 12 powders.

17.—Change to Apothecaries' weights and measures.

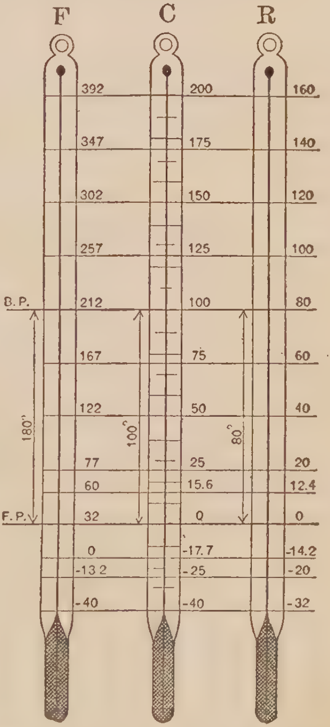
℞	Codeinæ sulphatis	0.13	Gm.
	Ammonii chloridi	8.	Gm.
	Syrupi tolutani	60.	Mils
	Aquæ	ad 90.	Mils

Note.—When changing weights and measures from one system to those of another by the use of equivalents, the answer frequently contains a decimal which may be eliminated by multiplying the decimal by the number of units of a lower denomination required to make one of the given denomination.

For example: If the answer is 12.84 Avoirdupois ounces. The decimal (.84) may be changed to grains by multiplying by 437.5, the number of grains in one Avoirdupois ounce; thus $0.84 \times 437.5 = 367.5$ grains.

THERMOMETERS—TEMPERATURE

Three kinds of thermometers are used for measuring heat: Fahrenheit, Centigrade, and Réaumur. The first is the domestic thermometer of the United States and Great Britain. The second is used for scientific purposes; the third is rarely used in this country.



The boiling point of water is 212° F., 100° C., 80° R. The freezing point of water is 32° F., 0° C., 0° R. The difference between the freezing- and the boiling-points of water is 180° F., 100° C., and 80° R.

Since 180° F. are equal to 100° C., each degree F. is equal to $^{100}/_{180} = ^{5}/_{9}$ of a degree Centigrade, or $^{80}/_{180} = ^{4}/_{9}$ of a degree Réaumur. In a similar manner we find that one degree Centigrade is equal to $^{9}/_{5}$ of a degree Fahrenheit, or $^{4}/_{5}$ of a degree Réaumur. One degree Réaumur is equal to $^{9}/_{4}$ of a degree Fahrenheit, or $^{5}/_{4}$ of a degree Centigrade.

A good idea of the construction of the scales of different thermometers may be obtained by studying the illustration. The zero of the Fahrenheit thermometer is 32 degrees below the zero of other thermometers. It is therefore necessary to subtract 32 from Fahrenheit degrees, before multiplying by the equivalent, when changing to other degrees. And for the same reason, 32 degrees must be added, after multiplying by the equivalent, when changing to Fahrenheit.

The following formulas may be used to reduce degrees from one scale to those of another:

$F° - 32 \times 5/9 = C°$	$C° \times 9/5 + 32 = F°$
$F° - 32 \times 4/9 = R°$	$R° \times 9/4 + 32 = F°$
$R° \times 5/4 = C°$	$C° \times 4/5 = R°$

5.—TO CONVERT FAHRENHEIT TO CENTIGRADE

1.—*Example.*—Convert 140° Fahrenheit to Centigrade.
140° — 32° = 108°; 5/9 of 108° = 60°, or 108° ÷ 1.8 = 60°.

PROBLEMS

						Ans.
2.—Convert	68°	Fahrenheit	to	Centigrade.	20° C.
3.—	"	23°	"	"	"	— 5° C.
4.—	"	— 22°	"	"	"	— 30° C.
5.—	"	390°	"	"	"	
6.—	"	244°	"	"	"	
7.—	"	— 40°	"	"	"	
8.—	"	70°	"	"	"	

6.—TO CONVERT CENTIGRADE TO FAHRENHEIT

1.—*Example.*—Convert 210° Centigrade to Fahrenheit.
9/5 of 210° = 378°; 378° + 32° = 410° C., or 210° × 1.8 + 32° = 410° C.

PROBLEMS

					Ans.
2.—Convert	250°	Centigrade	to	Fahrenheit.	482° F.
3.— "	— 40°	"	"	"	— 40° F.
4.— "	30°	"	"	"	
5.— "	— 10°	"	"	"	
6.— "	— 30°	"	"	"	
7.— "	— 4°	"	"	"	
8.— "	22°	"	"	"	

7.—TO CONVERT CENTIGRADE TO RÉAUMUR

1.—*Example.*—Convert 80° Centigrade to Réaumur.
4/5 of 80° = 64° R.

PROBLEMS

Ans.
2.—Convert 72.5° Centigrade to Réaumur. 58° R.
3.— " 350° " " "
4.— " — 40° " " "
5.— " 25° " " "

8.—TO CONVERT RÉAUMUR TO CENTIGRADE

1.—*Example.*—Convert 80° Réaumur to Centigrade.
5⁄4 of 80° = 100° R.

PROBLEMS

Ans.
2.—Convert 640° Réaumur to Centigrade. 800° C.
3.— " 48° " " "
4.— " — 12° " " "

5.—If water boils at 80° Réaumur what is the boiling-point in Centigrade degrees?

9.—TO CONVERT FAHRENHEIT TO RÉAUMUR

1.—*Example.*—Convert 77° Fahrenheit to Réaumur.
77° — 32° = 45°; 4⁄9 of 45° = 20° R.

PROBLEMS

Ans.
2.—Convert 95° Fahrenheit to Réaumur degrees. 28° R.
3.— " — 13° " " " "
4.— " 23° " " " "
5.— " 70° " " " "

10.—TO CONVERT RÉAUMUR TO FAHRENHEIT

1.—*Example.*—Convert 80° Réaumur to Fahrenheit.
9⁄4 of 80° + 32° = 212° F.

PROBLEMS

Ans.
2.—Convert 32° Réaumur to Fahrenheit. 104° F.
3.— " 96° " " "
4.— " — 16° " " "
5.— " — 8° " " "
6.— " 14° " " "

SPECIFIC GRAVITY

It is not the purpose of this work to enter into the details of taking specific gravity, but rather to give problems illustrating the methods of calculating the results of manipulation.

Specific gravity may be defined as the relative weight of equal bulks or volumes of different bodies, water being taken as the standard. The object sought is always the weight of a volume of water equal to that of the substance, the specific gravity of which we wish to obtain, whether that substance be liquid or solid, soluble or insoluble, heavier or lighter than water. The specific gravity is then obtained by *dividing the weight of the substance by the weight of an equal volume of water.*

SPECIFIC GRAVITY HYDROMETERS

The specific gravity of liquids is usually taken with hydrometers or specific gravity flasks (pycnometers).

Hydrometers are instruments which, when floating in a liquid, show the specific gravity, density, or per cent., on a scale. The specific gravity hydrometer is so constructed that the number at the surface of the liquid represents the specific gravity. Hydrometers for liquids heavier than water are graduated from 2000 at the bottom, to 1000 at the top. That the reading may be more exact, it is customary to use five hydrometers for liquids heavier than water. The first is graduated from 1000 to 1200, the second from 1200 to 1400, the third from 1400 to 1600, the fourth from 1600 to 1800, and the fifth from 1800 to 2000.

For liquids lighter than water, the hydrometer is graduated from 1000 at the bottom to 700 at the top.

The specific gravity hydrometer should sink in pharmacopœial hydrochloric acid to 1158, in sulphuric acid to 1840, in alcohol to 816 and in ether to 716. By pointing off three decimal places, if the instrument is not so marked, we have the respective specific gravities without calculation.

Hydrometers giving the per cent. by weight or volume are constructed for special purposes, as alcoholometers, which are so graduated that the reading gives the actual per cent. of absolute alcohol that the liquid contains.

Baumé hydrometers are constructed for use in both light and heavy liquids. The scale gives arbitrary degrees, which may be converted into specific gravity as follows:

To change Baumé Degrees to Specific Gravity.

11.—FOR LIQUIDS HEAVIER THAN WATER

1.—*Example.*—Change 60° Baumé to specific gravity.

$$\frac{145}{145 - 60} = \frac{145}{85} = 1.7058 \text{ Sp. Gr.}$$

PROBLEMS

2.—What is the specific gravity of hydrochloric acid, 20° Baumé?
Ans. 1.16 Sp. Gr.

3.—To what point will a specific gravity hydrometer sink in glycerin when a Baumé hydrometer sinks to 29°? Ans. 1.25.

4.—What is the specific gravity of sulphuric acid, 45° Baumé?

5.—If a Baumé hydrometer sinks to 35° in a solution of sugar, what is the specific gravity of the syrup?

12.—FOR LIQUIDS LIGHTER THAN WATER

1.—*Example.*—Change 56° Baumé to specific gravity.

$$\frac{140}{130 + 56} = \frac{140}{186} = 0.752 \text{ Sp. Gr.}$$

PROBLEMS

2.—What is the specific gravity of ammonia water, 24° Baumé?
Ans. 0.909.

3.—What is the specific gravity of alcohol, 40° Baumé?
4.—Change 60° Baumé to specific gravity.

To Change Specific Gravity to Baumé Degrees

13.—FOR LIQUIDS LIGHTER THAN WATER

1.—*Example.*—Change specific gravity 0.750 to Baumé.

$$\frac{140}{0.750} - 130 = 56.66° \text{ Bé.}$$

PROBLEMS

2.—What is the degree Baumé of ammonia which has a specific gravity of 0.9655? Ans. 15° Bé.
3.—Change the following specific gravities to Baumé degrees:—0.765, 0.979, 0.909, 0.800.

14.—FOR LIQUIDS HEAVIER THAN WATER

1.—*Example.*—Change specific gravity 1.24 to Baumé degrees.

$$145 - \frac{145}{1.24} = 28.1° \text{ Baumé.}$$

PROBLEMS

2.—How many degrees Baumé is sulphuric acid which has a specific gravity of 1.84? Ans. 66.2° Bé.
3.—What are the degrees Baumé of a syrup having a specific gravity of 1.124? Ans. 15.997° Bé.
4.—Change specific gravities 1.576 and 1.45 to Baumé degrees.

15.—TO CHANGE TWADDELL DEGREES TO SPECIFIC GRAVITY

Twaddell's hydrometer is for liquids heavier than water. Each degree equals 0.005 of a specific gravity degree.

1.—What is the specific gravity of sulphuric acid if Twaddell's hydrometer floats at 168°?

$168 \times 0.005 + 1 = 1.84$ specific gravity.

PROBLEM

2.—Change the following Twaddell's degrees to specific gravity; 50°, 80°, and 125°.

16.—TO CHANGE SPECIFIC GRAVITY TO TWADDELL DEGREES

1.—*Example.*—What degree, Twaddell, is hydrochloric acid, specific gravity, 1.16?

$$\frac{1.16 - 1}{0.005} = 32° \text{ T.}$$

PROBLEM

2.—To what degree will a Twaddell's hydrometer sink in the following pharmacopœial preparations: Nitric acid, solution ferric chloride, and syrup?

17.—SPECIFIC GRAVITY FLASKS OR PYCNOMETERS

The majority of specific gravity flasks are constructed to hold 25, 50, or 100 grams at a given temperature, and in some cases 250, 500, and 1000 grains, but the latter are rapidly passing out of use. When the flask holds exactly 100 grams of water at the proper temperature, the same flask will hold 71.6 grams of ether or 149 grams of chloroform, which, if divided by 100, will give the specific gravity of each liquid. Therefore, when the same flask is filled with any liquid, we have only to divide the weight of the contents of the flask by 100 to obtain the specific gravity. In like manner, if the flask contains 25 grams of water we have only to multiply the weight of its contents, when filled with *any liquid,* by 0.04, or to divide by 25, to obtain the specific gravity.

An ordinary light flask holding from 20 to 100 grams may be used in taking the specific gravity of liquids. The flask is dried and weighed, filled with water at the proper temperature and weighed again, and the weight of the flask subtracted; the difference is the weight of the water.

In the same manner find the weight of the contents of the flask when filled with any desired liquid.

1.—*Example.*—A flask weighs 20 grams; when filled with water it weighs 44 grams, and when filled with glycerin 50 grams. What is the specific gravity of the glycerin?

Subtracting the weight of the bottle in each case, we have 24 grams as the weight of the water, and 30 grams as the weight of the glycerin. $30 \div 24 = 1.25$, the Sp. Gr. of the glycerin.

PROBLEMS

2.—How many grams of glycerin, Sp. Gr. 1.25, will a 100-gram flask hold? Ans. 125 grams.

3.—A flask holds 25 grams of water. The same flask holds 29 grams of hydrochloric acid. What is the specific gravity of the acid? Ans. 1.16 Sp. Gr.

4.—How many grams of chloroform, specific gravity 1.49, will a 50-mil flask hold?

5.—If a bottle holds 1826 grams of sulphuric acid, U. S. P., how many grams of water will it hold?

6.—If 250 miles of ether weigh 181.25 grams, what is the specific gravity of the ether?

7.—What is the specific gravity of syrup when a fluidounce weighs 600.1 grains.

8.—What is the specific gravity of alcohol, when one liter weighs 820 Gm.?

9.—What is the specific gravity of aqua ammonia, when a bottle holds 50 grams of water or 48 grams of aqua ammonia?

10.—A bottle weighing one Apothecaries' ounce, when filled with water, weighs 2 oz. 6 dr. and 48 grains; when filled with hydrochloric acid it weighs 3 ounces. What is the specific gravity of the acid?

18.—TO TAKE THE SPECIFIC GRAVITY OF LIQUIDS WITH A PLUMMET

The specific gravity of liquids may be found by weighing a solid in water, and again in the liquid of which the specific gravity is desired. If a solid body be weighed in water and also in air, the difference in the weights is the weight of a volume of water equal to the volume of the solid. If the same solid is weighed in any other liquid and the weight subtracted from the weight in air, the difference is the weight of a volume of liquid equal to the volume of the solid, or to the weight of the same volume of water.

1.—*Example.*—A piece of glass weighing 39 grams in air weighs 24 grams in water, and 20.25 grams in glycerin. What is the specific gravity of the glycerin?

39 — 24 = 15, the weight of water displaced.
39 — 20.25 = 18.75, the weight of glycerin displaced.
18.75 ÷ 15 = 1.25, the specific gravity of the glycerin.

PROBLEMS

2.—A piece of glass weighs 39 grams in air, 24 grams in water, and 27.75 grams in ether. What is the specific gravity of the ether?
Ans. 0.750 Sp. Gr.

3.—The same piece of glass weighs 16.65 grams in chloroform. What is the specific gravity of the chloroform?
Ans. 1.49 Sp. Gr.

4.—If the same piece of glass weighs 27.6 grams less in sulphuric acid than in air, what is the specific gravity of the acid?

5.—56.75 grams of lead weigh 51.75 grams in water, and 52.5 grams in alcohol. What is the specific gravity of the alcohol?

6.—A piece of copper loses 14 grams when weighed in water, and 17.5 grams when weighed in glycerin. What is the specific gravity of the glycerin?

Note.—If a piece of glass be made of such a size that it will displace exactly 10 grams of water, then the loss of weight in any liquid divided by ten will give the specific gravity. If the specific gravity of glass in 2.600, then a piece weighing 26 grams will displace 10 grams of water, 12.4 grams of glycerin, or 7.16 grams of ether.

19. TO DETERMINE THE SPECIFIC GRAVITY OF SOLIDS INSOLUBLE IN, BUT HEAVIER THAN, WATER

Weigh the solid in air. Suspend in water by means of a silk thread, and weigh again. The difference in weight is the weight of the water displaced, and is equal in volume to the volume of the solid.

1.—*Example.* A piece of native lead sulphide weighs in air 108.75 grams, in water 93.75 grams. What is its specific gravity?

108.75 — 93.75 = 15. 108.75 ÷ 15 = 7.25 Sp. Gr.

PROBLEMS

2.—What is the specific gravity of a piece of lead weighing 35.412 grams in air and 32.292 grams in water? Ans. 11.35 Sp. Gr.

3.—A piece of copper weighs 34.008 grams in water, and 38.333 grams in air. What is the specific gravity?

4.—What is the weight of water displaced by a piece of silver, specific gravity 10.25 which weighs 27.162 grams in air?

5.—What is the weight of a piece of silver, specific gravity 10.25, which displaces 5 grams of water?

20.—SOLIDS INSOLUBLE IN, BUT LIGHTER THAN, WATER

Weigh the substance in air and attach it to a sinker of known weight. Weigh in water and subtract the weight of both in water from the weight of both in air. The difference is the loss in weight of both in water. Find separately what the sinker loses in water and subtract this from what they both lose in water. The difference is the loss in weight of the substance in water.

1.—*Example.*—A piece of lead weighs 11.35 grams in air, and 10.35 grams in water. The lead is attached to a piece of wax weighing 2.16 grams in air, and their weight, taken together in water, is 10.26 grams. Find the specific gravity of the wax.

$11.35 + 2.16 = 13.51$, the weight of both in air.

$13.51 - 10.26 = 3.25$, the loss in weight of both in water.

$11.35 - 10.35 = 1$, the loss in weight of the sinker in water.

$3.25 - 1 = 2.25$, the loss in weight of the wax in water.

$2.16 \div 2.25 = 0.96$, the Sp. Gr. of the wax.

A somewhat shorter method is the following:

Weigh the substance in air; weigh the sinker in water. Attach the substance to the sinker, and weigh both in water.

Take the above example without the weight of the sinker in air.

$10.35 + 2.16 = 12.51$, the weight of the sinker in water plus the weight of the substance in air.

$12.51 - 10.26 = 2.25$, the loss in weight of the wax in water.

$2.16 \div 2.25 = 0.96$, the Sp. Gr. of the wax.

PROBLEMS

2.—A piece of lead weighs 17.706 grams in air and 16.146 grams in water. A piece of spermaceti weighs 14.65 grams in air. Spermaceti and lead in water weigh 15.296 grams. What is the specific gravity of the spermaceti?

Ans. 0.945 Sp. Gr.

3.—Weight of wax in air.................... 5 Gm.
" " sinker in air .... 20 Gm.
" " " " water................ 18 Gm.
" " " and wax in water...... 17.8 Gm.
Find the specific gravity of the wax. Ans. 0.96 Sp. Gr.

4.—A cork weighs 9 grams in air. A sinker weighs 38 grams in water. The cork and sinker together weigh 3.25 grams in water. What is the specific gravity of the cork?

5.—A piece of copper weighs 17.68 grams in air, and 15.68 grams in water. A piece of cacao butter weighs 12.125 grams in air. The copper and cacao butter together weigh 15.305 grams in water. What is the specific gravity of the cacao butter?

6.—A piece of paraffin weighs 13.80 grams. A piece of brass weighs 9 grams in water. The paraffin and brass together weigh 7.8 grams in water. What is the specific gravity of the paraffin?

7.—What is the specific gravity of a piece of wood which weighs 18 grams? When attached to a piece of brass and suspended in water, both weigh 3.6 grams. The brass weighs 7 grams in water.

21.—TO FIND THE SPECIFIC GRAVITY OF POWDERS INSOLUBLE IN WATER

Fill a specific gravity flask with water and weigh; empty the flask, introduce a weighed quantity of the powder, fill with water and weigh again. Add the weight of the powder to the weight of the flask filled with water, and from this amount subtract the weight of the flask containing the powder and water. The difference is the weight of water displaced.

1.—*Example.*—A bottle filled with water weighs 58 grams. The bottle containing 12 grams of sand and filled with water weighs 65.2 grams. Find the specific gravity of the sand.

$$58 + 12 = 70.$$
$$70 - 65.2 = 4.8, \text{ the weight of water displaced.}$$
$$12 \div 4.8 = 2.5, \text{ the Sp. Gr. of the sand.}$$

PROBLEMS

2.—Place 56.75 grams of lead shot in a specific gravity flask. The flask is then filled with water and is found to weigh 116.75 grams. The flask filled with water weighs 65 grams. What is the specific gravity of the shot? Ans. 11.35 Sp. Gr.

3.—A bottle filled with water weighs 24 grams. If 13.8 grams of granulated zinc be introduced into the bottle, and the bottle filled with water, the combined weight will be 35.8 grams. What is the specific gravity of the zinc? Ans. 6.9 Sp. Gr.

4.—How many grams of water will be displaced by 1035 grams of zinc, specific gravity 6.9? Ans. 150 Gm.

5.—Weight of mercuric oxide .... 38.5 Gm.
Weight of bottle filled with water .... 35 Gm.
Weight of bottle containing mercuric oxide, when filled with water .... 70 Gm.
Find the specific gravity of the mercuric oxide.

6.—When 33.488 grams of mercuric sulphate are placed in a bottle and the bottle filled with water, the combined weight is 68.79 grams. The weight of the bottle filled with water is 40.502 grams. What is the specific gravity of the mercuric sulphate?

7.—How many grains of water will be displaced by an Avoirdupois pound of mercury, specific gravity 13.56?

8.—How many grams of mercury will an ounce bottle hold?

22.—TO DETERMINE THE SPECIFIC GRAVITY OF SOLIDS SOLUBLE IN WATER

The method employed is the same as in taking the specific gravity of solids insoluble in water, except that, in place of water, some other liquid is used in which the substance is insoluble, as oil, alcohol, or turpentine. A correction is then made for the difference in the specific gravity of the liquid used and that of water, by multiplying by the specific gravity of the liquid.

1.—*Example.*—A crystal of potassium dichromate weighs 19.705 grams in air and 13.27 grams in deodorized alcohol, specific gravity 0.816. What is the specific gravity of the potassium dichromate?

19.705 — 13.27 = 6.435, the loss of weight in alcohol.

19.705 ÷ 6.435 = 3.062, the specific gravity as compared with alcohol.

3.062 × 0.816 = 2.495, the specific gravity as compared with water.

PROBLEMS

2.—What is the specific gravity of copper sulphate, if a piece weighs 20.311 grams in air and 12.359 grams in turpentine having a specific gravity of 0.86? Ans. 2.196 Sp. Gr.

3.—A piece of borax weighs 23.62 grams in air and 12.323 grams in alcohol, specific gravity 0.816. What is the specific gravity of the borax? Ans. 1.706 Sp. Gr.

4.—A specific gravity flask filled with chloroform weighs 98.092 grams; 12 grams of salt are placed in the flask and the flask filled with chloroform. The weight of the flask, salt, and chloroform is 101.64 grams. The specific gravity of the chloroform is 1.49. What is the specific gravity of the salt? 2.11

5.—The capacity of a specific gravity bottle is 50 grams of water or 43.686 grams of benzin. If 16 grams of potassium chlorate are added to the bottle and filled with benzin the contents weigh 53.244 grams. What is the specific gravity of the potassium chlorate? 2.17

6.—A specific gravity bottle weighs 20.5 grams. When filled with water it weighed 70.5 grams; when filled with ether it weighed 56.75 grams; 25 grams of sugar are placed in the bottle and the latter filled with ether, it then weighs 70.279 grams. What is the specific gravity of the sugar? 1.57

SPECIFIC VOLUME

Specific volume is the volumetric ratio existing between the same weights of different bodies, as compared with the volume of the same weight of water. It is, therefore, the reciprocal of specific gravity. In pharmaceutical practice its use is confined to liquids. Specific volume may be found by dividing the volume of a given weight of the liquid by the volume of an equal weight of water.

23.—TO FIND THE SPECIFIC VOLUME OF A LIQUID

1.—***Example.***—100 grains of glycerin measure 84 minims. 100 grains of water measure 105 minims. What is the specific volume of the glycerin?

84 ÷ 105 = 0.8, the specific volume of the glycerin.

A given weight of liquid cannot be as accurately measured as a given volume of liquid can be weighed. Therefore, a better method is to find the specific gravity and divide 1 by the specific gravity.

Example.—The specific gravity of glycerin is 1.25. 1 ÷ 1.25 = 0.80, the specific volume of the glycerin.

PROBLEMS

2.—What is the specific volume of stronger ammonia water, specific gravity 0.90? Ans. 1.111 Sp. Vol.

3.—Find the specific volume of nitric acid, specific gravity 1.420. Ans. 0.7042 Sp. Vol.

4.—The specific gravity of bromine is 2.990. What is its specific volume? .330

5.—What is the volume of 50 grams of chloroform, specific gravity 1.49? 33.55

6.—How many mils in 50 grams of ether, specific gravity 0.725?

7.—What is the specific volume of chloroform if 1000 grains measure 1.473 fluidounces, and the same weight of water measures 2.195 fluidounces? .671

24.—TO FIND THE VOLUME OF A GIVEN WEIGHT OF ANY LIQUID

1.—*Example.*—How many fluidounces in 50 Avoirdupois ounces of glycerin? 50 × 0.96 (the equivalent in fluidounces of one Avoirdupois ounce of water) = 48, which is the equivalent in fluidounces of 50 Avoirdupois ounces. 48 × 0.8 (the specific volume of glycerin) = 38.4 fluidounces of glycerin; or we may divide by the specific gravity instead of multiplying by the specific volume.

(*a*) $50 \times 0.96 \times 0.8 = 38.4$ or,
(*b*) $50 \times 0.96 \div 1.25 = 38.4$ fluidounces.

PROBLEMS

2.—How many fluidounces in 75 Apothecaries' ounces of sulphuric acid, Sp. Gr. 1.84? Ans. 42.86 fl. oz.

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3.—How many fluidounces in 150 Av. oz. of nitric acid, Sp. Gr. 1.42? Ans. 101.4 fl. oz.

4.—How many fluidounces in 400 grams of olive oil, Sp. Gr. 0.915?

5.—How many mils in 600 grams of hydrochloric acid, Sp. Gr. 1.16?

6.—What is the cost of 8 fluidounces of glycerin, Sp. Gr. 1.25, when 10 pounds cost $2.20?

7.—If a 500-gram bottle of chloroform, Sp. Gr. 1.49, costs $1.10, what is the cost of 1 fluidounce?

8.—In the following formula, change the quantities of the liquids to mils.

			Ans.	
Pepsin	40	Gm.		
Hydrochloric acid	12	"	10.344	Mils
Glycerin	406.25	"	325	"
Water	660	"	660	"

9.—How many fluidounces will be formed by mixing a pound of chloroform with a pound of ether, no allowance being made for contraction?

25.—TO FIND THE WEIGHT OF A GIVEN VOLUME OF ANY LIQUID

1.—*Example.*—How many Apothecaries' ounces in 100 fl. oz. of chloroform? 100 × 0.95 = 95 Apothecaries' ounces. 95 × 1.49, the Sp. Gr. of chloroform, = 141.55 Apoth. oz. of chloroform.

PROBLEMS

2.—What will one pint of chloroform, Sp. Gr. 1.49, cost if one pound costs 60 cents? Ans. 92.97 cents.

3.—What will one pint of ether, Sp. Gr. 0.716, cost if one pound costs 70 cents? Ans. 52.12 cents.

4.—What will 5 gallons of glycerin, Sp. Gr. 1.25, cost at 20 cents a pound?

5.—How many pounds in one pint of mercury, Sp. Gr. 13.535?

6.—How many grams in a quart of ether, Sp. Gr. 0.716?

7.—If 5 pints of sulphuric acid, Sp. Gr. 1.84, cost $1.15, what is the cost of one pound?

8.—If glycerin, Sp. Gr. 1.25, costs 22 cents a pound, what is the cost of a gallon?

26.—TO FIND THE VOLUME OF PURE SUBSTANCE IN A GIVEN WEIGHT OF LIQUID WHEN THE PER CENT. BY WEIGHT IS GIVEN

1.—*Example.*—A solution contains 10 per cent. by weight of glycerin. How many fluidounces of glycerin in 40 Apothecaries' ounces of the solution?

$$40 \times 0.10 \times 1.05 \div 1.25 = 3.36 \text{ fl. oz. of glycerin.}$$

PROBLEMS

2.—How many fluidounces of absolute alcohol, Sp. Gr. 0.79, in 150 Apothecaries' ounces of dilute alcohol containing 41.5 per cent. of alcohol? Ans. 78.79 fl. oz.

3.—How many mils of oil of anise in 750 grams of spirit of anise, if the spirit contains 13 per cent. of the oil, having a Sp. Gr. of 0.98? Ans. 99.49 mils.

4.—How many mils of ether, Sp. Gr. 0.716, and of alcohol, Sp. Gr. 0.816, in 810 grams of spirit of ether, which contains 30 per cent. of ether and 70 per cent. of alcohol?

5.—If white wine contains 12 per cent. by weight of alcohol, Sp. Gr. 0.79, how many fluidounces of alcohol are there in two quarts of wine, the specific gravity of the wine being the same as that of water?

27.—TO FIND THE WEIGHT OF PURE SUBSTANCE IN A GIVEN VOLUME OF LIQUID WHEN THE PER CENT. BY VOLUME IS GIVEN

1.—*Example.*—How many Apothecaries' ounces of absolute alcohol in 15 fluidounces of alcohol containing 60 per cent. by volume of absolute alcohol?

$15 \times 0.60 = 9$, the volume of absolute alcohol.

9×0.95 (to change from fl. oz. to Apothecaries') $= 8.55$.

$8.55 \times 0.797 = 6.814$ Apothecaries' ounces of absolute alcohol.

PROBLEMS

2.—Spirit of chloroform contains 6 mils of chloroform in 100 mils of the spirit. How many grams of chloroform, Sp. Gr. 1.49, in 7500 mils of the spirit? Ans. 670.5 grams.

3.—Spirit of cinnamon contains 10 per cent. by volume of the oil of cinnamon, which has a specific gravity of 1.06. How many grams of the oil are required to make two and a half liters of the spirit? Ans. 265 grams.

4.—Liniment of ammonia contains:

Ammonia water	Sp. Gr. 0.96	35%	by volume
Alcohol	Sp. Gr. 0.82	5%	"
Cotton-seed oil	Sp. Gr. 0.92	60%	"

How many Apothecaries' ounces of each will be required to make two pints of the above liniment?

5.—How many grams of glycerin, Sp. Gr. 1.25, in 4 liters of syrup of wild cherry which contains 15 per cent. by volume of glycerin?

6.—How many pounds of chloroform, Sp. Gr. 1.49, in a gallon of chloroform liniment which contains 30 per cent. by volume of chloroform?

28.—TO FIND THE PER CENT. BY VOLUME WHEN THE PER CENT. BY WEIGHT IS GIVEN

1.—*Example.*—A mixture of alcohol and water, having a specific gravity of 0.9, contains 58 per cent. by weight of alcohol. What is the per cent. by volume?

A unit weight of the solution contains 0.58 of a unit weight of absolute alcohol. This 0.58 of a unit weight divided by the specific gravity of absolute alcohol equals the volume of absolute alcohol which a unit weight of the solution contains, $\frac{0.58}{0.797} = 0.7277$. The volume of a unit weight of the solution is 1 divided by its specific gravity, $\frac{1}{0.9} = 1.111$. The volume of absolute alcohol divided by the volume of the solution equals the per cent. by volume, $0.7277 \div 1.111 = 0.6549$, the per cent. by volume.

Thus, $\frac{0.58}{0.797} \div \frac{1}{0.9} = 0.6549$, or $\frac{0.58}{0.797} \times 0.9 = 0.6549$.

PROBLEMS

2.—Alcohol having a specific gravity of 0.9135 contains 52 per cent. by weight of absolute alcohol. What is the per cent. by volume? Ans. 59.6 per cent.

3.—What is the per cent. by volume of absolute alcohol in a solution having a specific gravity of 0.9623 and containing 27 per cent. by weight of absolute alcohol? Ans. 32.59 per cent.

4.—Alcohol containing 38 per cent. by weight of absolute alcohol has a specific gravity of 0.943. What is the per cent. by volume?

5.—What is the per cent. by volume of commercial alcohol, Sp. Gr. 0.82, in a spirit containing 54.95 per cent. by weight of commercial alcohol and having a Sp. Gr. of 0.9184?

6.—What is the per cent. by volume of glycerin, Sp. Gr. 1.25, in a mixture having a Sp. Gr. of 1.143 and containing 55 per cent. by weight of glycerin?

7.—If spirit of ether has a Sp. Gr. of 0.7972 and contains 30 per cent. by weight of ether, Sp. Gr. 0.725, what is the per cent. by volume?

29.—TO FIND THE PER CENT. BY WEIGHT WHEN THE PER CENT. BY VOLUME IS GIVEN

1.—*Example.*—A solution of alcohol in water having a specific gravity of 0.9 contains 66 per cent. by volume of absolute alcohol. What is the per cent. by weight?

A unit volume of the solution contains 0.66 of a unit volume of absolute alcohol. 0.66 multiplied by the specific gravity of absolute alcohol equals the weight of absolute alcohol in a unit volume of the solution: $0.66 \times 0.797 = 0.526$. The weight of a unit volume of the solution is 1 multiplied by its specific gravity, $1 \times 0.9 = 0.9$. The weight of absolute alcohol divided by the weight of the solution equals the per cent. by weight: $0.526 \div 0.9 = 0.584$.

$0.66 \times 0.797 \div 0.9 = 0.584$ or 58.4 per cent. by weight.

PROBLEMS

2.—Dilute alcohol having a specific gravity of 0.9264 contains 54 per cent. by volume of absolute alcohol. What per cent. by weight does it contain? Ans. 46.45 per cent.

3.—What is the per cent. by weight of absolute alcohol in dilute alcohol having a specific gravity of 0.8557 and containing 83 per cent. by volume of absolute alcohol?

4.—A dilute alcohol containing 11 per cent. by volume of absolute alcohol has a specific gravity of 0.9857. What per cent. by weight of absolute alcohol does it contain?

5.—Tincture of ferric chloride has a specific gravity of 0.955 and contains 25 per cent. by volume of the solution of ferric chloride, which has a specific gravity of 1.315. What is the per cent. by weight?

6.—White wine having the same specific gravity as water contains 13 per cent. by volume of absolute alcohol. What per cent. by weight of absolute alcohol does it contain?

PERCENTAGE SOLUTIONS

Percentage solutions are manufactured by weight. Therefore, when the quantity to be prepared is given in fluid measure, *it must be changed to weight.*

30.—TO FIND THE AMOUNT OF SUBSTANCE REQUIRED TO MAKE A GIVEN QUANTITY OF A SOLUTION WHEN THE PER CENT. IS GIVEN

1.—*Example.*—Prepare two fluidounces of a four-per cent. solution of cocaine.

Two fluidounces of water weigh 911.4 grains. Four per cent. of 911.4 is 36.45 grains. 36.45 grains of cocaine are to be dissolved in sufficient water to make the total weight 911.4 grains.

PROBLEMS

2.—How many grains of mercury bichloride are required to make one pint of a 0.1-per cent. solution? Ans. 7.29 grains.

3.—How many grams of mercury bichloride are required to make 750 mils of a 1:1000 solution? Ans. 0.75 Gm.

4.—Carbolic acid solution, 4% .... f ℥ 2
Boric acid solution, 5% .... f ℥ 2
Mix.

How many grains of boric acid and carbolic acid are required in the above prescription?

Ans. Boric acid, 45.57 gr.; Carbolic acid, 36.45 gr.

5.—Make one fluidounce of a 2-per cent. veratrine oleate.

When the solvent does not have the same specific gravity as water, then the specific gravity of the solvent must be considered. A fluidounce of water weighs 455.7 grains; a fluidounce of oleic acid, having a specific gravity of 0.9, weighs $0.9 \times 455.7 = 410.13$ grains. $410.13 \times 0.02 = 8.2$ grains of veratrine to be added to sufficient oleic acid to make 410.13 grains.

6.—How many grains of boric acid are required to make 4 fluidounces of a 5-per cent. solution in glycerin, Sp. Gr. 1.25?

Ans. 113.9 grains of boric acid.

7.—How many grains of iodine are required to make 4 fluidounces of a 5-per cent. solution in alcohol, Sp. Gr. 0.82?

8.—How many grams of iodine must be dissolved in alcohol, specific gravity 0.82, to make 50 mils of 5-per cent. solution?

9.—Make half a fluidounce of carbolated oil containing 5 per cent. of carbolic acid.

If the specific gravity of the solvent is unknown, measure the required volume of the solvent and weigh it, then calculate the amount of the substance to be dissolved. Thus half a fluidounce of the oil weighs 208 grains; 5 per cent. of 208 grains is 10.4 grains, the amount of carbolic acid to be used. $208 - 10.4 = 197.6$, the number of grains of oil to be used.

In the preceding problems the amount of the medicament is so small that its volume has been considered equal to that of the solvent, but such is not the case. The volume occupied by various substances when dissolved in liquids is so variable that no definite correction can be given unless the specific gravity of the resulting solution is known. If the amount is small the decrease in volume need not be considered, but if more than 5 per cent., an allowance should be made for the decrease in volume, when the quantity ordered is by volume. A closer approximation of the desired volume may be obtained by taking a volume of the solvent equal to the volume of the desired product, according to the following:

31.—TO MAKE A SOLUTION OF A GIVEN STRENGTH WHEN THE QUANTITY OF THE SOLVENT IS GIVEN

1.—***Example.***—How many grams of potassium iodide must be dissolved in 484 mils of water to make a 12-per cent. solution?

The finished solution must contain 12 per cent. of potassium iodide and 88 per cent. of water. Then the 484 grams of water must be 88 per cent. of the finished solution and 1 per cent. is $\frac{1}{88}$ of 484, or 5.5 grams. If 5.5 is 1 per cent., then 12 per cent. is 12 times 5.5, or 66 grams of potassium iodide to be dissolved in 484 grams of water.

PROBLEMS

2.—How many grams of zinc sulphate must be dissolved in 470 grams of water to make a 6-per cent. solution? Ans. 30 grams. 5y6=3

3.—How many grains of boric acid must be dissolved in 4 fluidounces of water to make a 5-per cent. solution?

4.—How many grams of tannic acid must be dissolved in 320 mils of glycerin, Sp. Gr. 1.25, to make a 20-per cent. solution? What will be the weight of the solution?

5.—How many grains of cocaine must be dissolved in 2 fl. oz. oleic acid, Sp. Gr. 0.900, to make a 2-per cent. oleate?

WEIGHT-VOLUME

A less accurate method is sometimes followed, in which the fact is ignored that a minim does not weigh a grain. For example, certain manufacturing houses direct to make a 5-per cent. solution by dissolving 24 grains in 1 ounce of water. 24 is five per cent. of 480, which is the number of minims in a fluidounce. But 480 minims only weigh 455.7 grains. Hence, a solution containing 24 grains in a fluidounce, is a little over 5¼ per cent. Such solutions have been called " weight per volume."

The strengths of the tinctures are often stated in terms of per cent., but this is not strictly correct unless the tincture has the same specific gravity as water, which is seldom the case. Therefore when applying per cent. to tinctures it should be remembered that this is weight-volume or grams per 100 mils.

32.—TO REDUCE SOLUTIONS FROM A HIGHER TO A LOWER PERCENTAGE

When per cent. by volume is used, the proportional parts are by volume. When per cent. by weight is used the proportional parts are by weight.

When mixing liquids by volume that contract in volume when mixed, they should be allowed to stand until contraction ceases. Then add a sufficient quantity of the diluent to restore the required volume.

I.—By Volume

1.—*Example.*—Make 48.6-per cent. alcohol, by volume, from 94-per cent. alcohol, by volume.

Let the per cent. to which the strong liquid is to be diluted represent the volume of the strong liquid to be taken. Let the per cent. of the strong liquid represent the volume to which the strong liquid is to be diluted.

Thus take 48.6 volumes of 94-per cent. alcohol and add enough water to make 94 volumes.

II.—By Weight

2.—*Example.*—Make 41-per cent. alcohol, by weight, from 91-per cent. alcohol, by weight.

Let the required per cent. represent the number of weight-parts of the strong liquid to be taken. Let the per cent. of the strong liquid represent the number of weight-parts to which the strong liquid is to be diluted.

Take 41 parts by weight of 91-per cent. alcohol and add sufficient water to make 91 parts, by weight.

PROBLEMS

3.—How many volumes of 60-per cent. alcohol are required to make 60 volumes of 40-per cent. alcohol? Ans. 40 volumes.

4.—How many grams of 28-per cent. ammonia water must be taken to make 28 grams of 10-per cent. ammonia water?

5.—How many grams of strong sulphuric acid are required to make 92.5 grams of U. S. P. dilute sulphuric acid?

6.—How many mils of deodorized alcohol are required to make 95.1 mils of U. S. P. dilute alcohol?

In the preceding problems the number of parts may be considered as proportional, and, if a greater or less quantity is desired, the proportional parts may be multiplied or divided by the same number, as the case may require. In the third problem, instead of making 60 volumes, 180 volumes may be made by taking 3 times 40 volumes, or 120 volumes of 60-per cent. alcohol, and adding water to

3 times 60 volumes, or 180 volumes. Again 15 volumes may be made by taking one-fourth of 40 volumes, or 10 volumes of 60-per cent., and adding water to one-fourth of 60 volumes, or 15 volumes. The preceding is identical in practice with the following:

33.—TO MAKE A GIVEN QUANTITY OF SOLUTION OF A GIVEN STRENGTH, BY DILUTING A STRONG SOLUTION

1.—*Example.*—Make 370 grams of 10-per cent. sulphuric acid from 92.5 per cent. sulphuric acid.

$370 \times 0.10 = 37$, the quantity of absolute acid required.

$37 \div 0.925 = 40$, the number of grams of 92.5-per cent. sulphuric acid required.

$370 - 40 = 330$, the number of grams of water required.

PROBLEMS

2.—How many grams of glacial acetic acid are required to make 770 grams of 36-per cent. acid? 99 : 36 :: 770 : x Ans. 280 Gm.

3.—How many mils of 94-per cent. alcohol must be taken to make 517 mils of 50-per cent. alcohol? Ans. 275 mils of 94 per cent.

4.—How many Imperial fluidounces of 94-per cent. alcohol are required to make 23.5 Imperial fluidounces of 40-per cent. alcohol?

5.—How many Avoirdupois ounces of 68-per cent. nitric acid are required to make 17 Av. oz. of 10-per cent. acid?

6.—How many grams of 32-per cent. hydrochloric acid must be taken to make 192 grams of 10-per cent. acid?

7.—How many grains of 20-per cent. mercury oleate and oleic acid are required to make one Apothecaries' ounce of 5-per cent. mercury oleate?

8.—How many grams of 18-per cent. opium and sugar of milk are required to make 126 grams of 14-per cent. opium?

34.—TO REDUCE A GIVEN QUANTITY OF A SUBSTANCE, OF A GIVEN PER CENT., TO A LOWER PER CENT.

1.—*Example.*—Dilute 240 grams of 92-per cent. sulphuric acid to 12-per cent. acid.

240 × 0.92 = 220.8 grams of absolute sulphuric acid.
220.8 ÷ 0.12 = 1840 grams of 12-per cent.
1840 — 240 = 1600 grams of water to be added.

[illegible] 470 oz = 97

2.—How many mils of 48-per cent. alcohol can be made from 500 mils of 94-per cent. alcohol? Ans. 979.166 mils.

3.—How many avoirdupois ounces of 20-per cent. solution of zinc chloride can be made from 4 avoirdupois ounces of 50-per cent. solution of zinc chloride?

4.—How many drams of 6-per cent. mercury oleate may be made from 12 drams of 20-per cent. mercury oleate?

5.—How many avoirdupois ounces of dilute hydrochloric acid can be made from 4 avoirdupois ounces of U. S. P. hydrochloric acid?

4) [illegible] 12 [illegible] x = [illegible]

5) 10 : 33 = 4 : x ; x = 13.2 [illegible]

ALLIGATION

The application of the principles of alligation to the practice of pharmacy admits of extended use.

Alligation, as applied to pharmacy, is the method of ascertaining the quantities of substances of different strengths required to be mixed in order to produce a certain mixture of a given strength.

35.—ALLIGATION APPLIED TO PHARMACY

1.—***Example.***—In what proportion must 12-per cent. and 17-per cent. powdered opium be mixed to produce a 14-per cent. opium?

If one part of a 17-per cent. opium is taken, 3 per cent. is gained. To gain 1 per cent. only $\frac{1}{3}$ of a part of 17-per cent. opium must be taken. If one part of 12-per cent. opium is taken 2 per cent is lost. To lose 1 per cent. only $\frac{1}{2}$ of one part must be taken. If $\frac{1}{3}$ of one part of 17-per cent. and $\frac{1}{2}$ of one part of 12-per cent. are mixed, the gain and loss will balance and a 14-per cent. will be produced. If we multiply both fractions by the same number we do not change the proportion. Therefore, we may take any number of times $\frac{1}{3}$ and $\frac{1}{2}$ and the strength of the resulting mixture will be the same.

Find the quantity, the strength of which is greater than the mean rate, that must be taken to gain one of the same denomination as the mean rate. Find the quantity, the strength of which is less than the mean rate, that must be taken to lose one of the same denomination as the mean rate. Change the fractions, if there are any, to whole numbers. The result is the number of parts of each that must be taken to produce the mean rate.

14	17	$\frac{1}{3} \times 6 = 2$,	2 parts of 17% opium
	12	$\frac{1}{2} \times 6 = 3$,	3 parts of 12% opium
		Make	5 parts of 14% opium

Observe that the number in the final result, in each case, is the same as the figure of the denominator of the fraction, of the substance with which it is to be mixed. From which we deduce the following:

Subtract the required per cent. from the greater per cent. and place the difference opposite the lower per cent. Also subtract the lower per cent. from the required per cent. and place the difference opposite the greater per cent. The figures opposite each are the required result.

Thus:

14	17	2,	2 parts of 17%
	12	3,	3 parts of 12%
			5 parts of 14%

PROBLEMS

2.—In what proportion must a 6-per cent. and a 14-per cent. drug be mixed to produce one of 8-per cent.?

Ans. 1 part of 14-per cent. and 3 parts of 6-per cent.

3.—In what proportion must 92-per cent. alcohol and 20-per cent. alcohol be mixed to produce 40-per cent. alcohol?

Ans. 13 parts of 20-per cent., and 5 parts of 92-per cent.

4.—Mix 8-per cent. and 28-per cent. ammonia water to make 10-per cent. ammonia water.

5.—In what proportion must 28-per cent. ammonia water and water be mixed to produce 10-per cent. ammonia water?

When per cent. by weight is used, the proportionate parts are by weight. When per cent. by volume is used the proportionate parts are by volume.

When mixing liquids by measure that contract in volume when mixed, they should be allowed to stand until

2) 8 | 14 | - 2 | 4 [illegible]

contraction ceases. Then add sufficient quantity of the diluent to make the required volume.

36.—TO FIND THE AMOUNTS NECESSARY TO MAKE A GIVEN QUANTITY

The preceding results are proportional parts, and any multiple of them may be taken so long as their relative proportions are retained. Therefore, if it is desired to make a given amount, it is only necessary to take as many times the number of parts as their sum is contained times in the required amount.

1.—*Example.*—How many ounces of 12- and 18-per cent. powdered opiums are required to make 24 ounces of 14-per cent. opium?

14	18	2	1 part of 18-per cent. opium.
	12	4	2 parts of 12-per cent. opium.
			3 parts of 14-per cent. opium. 24 ÷ 3 = 8

8 × 1 = 8, or 8 oz. of 18-per cent. opium.
8 × 2 = 16, or 16 oz. of 12-per cent. opium.
Make 24 ounces of 14-per cent. opium.

PROBLEMS

2.—How many grams of 16-per cent. and 10-per cent. opiums must be used to make a kilogram of 14-per cent. opium?

Ans. 666.666 Gm. of 16-per cent.
333.333 Gm. of 10-per cent.

3.—How many grams of sugar of milk must be mixed with a 25-per cent. triturate to produce 10 grams of a 10-per cent. triturate?

[illegible] Ans. 6 Gm. sugar of milk.

4.—How many fluidounces of water and 28-per cent. ammonia water are required to make one quart of 10-per cent. ammonia water? As the per cent. of ammonia gas is by weight, a correction must be made for the difference in specific gravity.

5.—How many grams of 1.5 per cent. and 4-per cent. hydrogen peroxide water must be mixed to make 100 grams of 3-per cent. hydrogen peroxide water?

6.—How many avoirdupois ounces of U. S. P. hydrochloric acid and water must be mixed in order to produce one pint of 10-per cent. hydrochloric acid?

37.—TO FIND THE AMOUNT OF ONE INGREDIENT WHEN THE AMOUNT OF THE OTHER IS GIVEN

1.—*Example.*—How many ounces of sugar of milk must be mixed with 20 ounces of a 12-per cent. triturate to make a 5-per cent. triturate?

$$\begin{array}{c|c|c||l} & 12 & 5 & 20 \div 5 = 4 \\ 5 & & & \\ & 0 & 7 & \end{array}$$

Seven parts of sugar of milk are required for every five parts of triturate; as there are 20 parts of triturate it will require 4 × 7, or 28 parts of sugar of milk.

PROBLEMS

2.—How many avoirdupois ounces of water must be added to 30 avoirdupois ounces of 25-per cent. nitric acid to produce a 5-per cent. nitric acid? Ans. 120 Av. oz.

3.—How many grams of 20-per cent. alcohol must be added to 1000 grams of 80-per cent. alcohol to make a 55-per cent. alcohol? Ans. 714.285 Gm.

4.—Given 10 Apothecaries' ounces of 91-per cent. alcohol to make a 45.5 per cent. alcohol. How many ounces of 20-per cent. alcohol are required?

5.—Desired to make a solution containing 20 per cent. of hydrochloric acid, using 80 grams of strong U. S. P. acid, and a sufficient quantity of dilute U. S. P. acid. How many grams of the latter are required?

6.—How many ounces of 92-per cent. alcohol must be added to 100 ounces of 30-per cent. alcohol to make a 50-per cent. alcohol?

7.—Given 25 ounces of 15-per cent. alcohol to make 45-per cent. alcohol. How many ounces of 85-per cent. alcohol are required?

38.—WHEN MORE THAN TWO SUBSTANCES OF DIFFERENT STRENGTHS ARE TO BE MIXED

1.—*Example.*—In what proportion must 8-, 10-, 16-, and 18-per cent. opiums be mixed to form a 14-per cent. opium?

14	8	4	2, 2 parts of 8% opium.
	10	2	1, 1 parts of 10% "
	16	4	2, 2 parts of 16% "
	18	6	3, 3 parts of 18% "

When an odd number of substances are used, or when the number of weaker per cents. exceed the stronger, or vice versa, some of the terms must be used more than once. Thus:

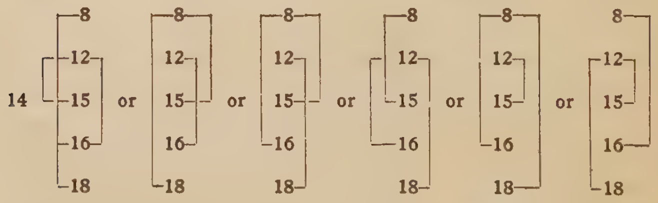
2.—***Example.***—In what proportion must 8-, 16-, and 18-per cent. opiums be mixed to form a 14-per cent. opium?

14	8	2	4	6	1 part of 8% opium	= 3 parts of 14% opium.
	16	6		6	1 part of 16% opium	
	18		6	6	1 part of 18% opium	

Write the per cents. in a column. Connect each one of the terms which is less than that of the required term with one that is greater, and each of those that is greater with one that is less. Solve each couplet as before.

When there are several different terms, as many different results may be obtained as different couplets can be formed.

3.—***Example.***—Obtain different results by mixing 18-, 16-, 15-, 12-, and 8-per cent. to form 14-per cent. Thus:



The student may secure as many different results as possible from the following problems.

PROBLEMS

4.—In what proportion, by volume, must 90-, 85-, 80-, 45-, 30-, 25-, and 20-per cent. alcohols be mixed to produce a 40-per cent. alcohol?

5.—Mix 92-, 84-, 16-, and 8-per cent. sulphuric acids, to produce a 48-per cent. acid by weight.

6.—How many grams of 90-, 60-, 40-, and 10-per cent. sulphuric acids are required to make a 20-per cent. acid by weight?

39.—WHEN THE QUANTITIES OF MORE THAN ONE OF THE TERMS ARE GIVEN

1.—***Example.***—How many grams of water are required to make a 10-per cent. sulphuric acid from 25 grams of 30-per cent. and 50 grams of 60-per cent. sulphuric acids?

If we mix 25 grams of 30-per cent. with 50 grams of 60-per cent., we will have 75 grams of 50-per cent. Thus:

$$\begin{array}{lr} 25 \times 30 = & 750 \\ 50 \times 60 = & 3000 \\ 75 & 3750 \end{array} \qquad 3750 \div 75 = 50$$

The question now becomes, how many grams of water are required to make 10-per cent. sulphuric acid from 75 grams of 50-per cent. sulphuric acid?

	50	10	1 part of 50% sulphuric acid.
10			
	0	40	4 parts of water.

If 1 gram of 50-per cent. sulphuric acid requires 4 grams of water, 75 grams will require 75 times 4 grams, or 300 grams of water.

2.—How many grains of 18-per cent. opium must be mixed with 50 grains of 12-per cent., 80 grains of 13-per cent., and 40 grains of 10 per cent. opiums to make powdered opium containing 14 per cent. morphine? Ans. 85 grains of 18-per cent.

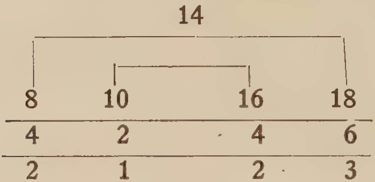
3.—A pharmacist has recovered 200 mils of alcohol, having a specific gravity of 0.8526, and 450 mils of alcohol having a specific gravity of 0.909. How many mils of alcohol, 92-per cent., must be added to make an 88-per cent. alcohol? 9

Note.—From the alcohol tables of the Pharmacopœia find the per cent. by volume corresponding to the specific gravities, given at 15° C., and proceed as before.

4.—How many grams of oleic acid must be added to 10 grams of 20-per cent. and 25 grams of 15-per cent. oleates of mercury to make a 5-per cent. oleate of mercury?

5.—How many avoirdupois ounces of carbolic acid, 95-per cent., is it necessary to add to 12 ounces of 5-per cent. and 16 ounces of 12-per cent. to make a solution containing 15 per cent. of carbolic acid?

Alligation may also be expressed in the following form:



Therefore, 2 of 8-per cent., 1 of 10-per cent., 2 of 16-per cent., and 3 of 18-per cent. must be mixed to produce 14-per cent.

40.—ALLIGATION APPLIED TO THE MIXING OF LIQUIDS OF DIFFERENT SPECIFIC GRAVITIES

Alligation may be employed in mixing liquids of different specific gravities, when no change in volume occurs. The process is the same as in articles 35 to 39, except that specific gravities are used in place of per cents. *The ratios are by volume.*

1.—*Example.*—In what proportion must glycerin, specific gravity 1.25, and water be mixed to produce a specific gravity of 1.10?

1.10	1.25	10	2 parts of glycerin.
	1.00	15	3 parts of water.

2.—How many mils of hydrochloric acid, specific gravity 1.20, must be mixed with 150 mils of hydrochloric acid, specific gravity 1.10, to produce an acid having a specific gravity of 1.16?

Ans. 225 mils.

120 | 6 3
110 | 4 2 150 : 2 : : x :

3.—How many mils of water must be added to 84 mils of nitric acid, Sp. Gr. 1.42, to make an acid having a Sp. Gr. of 1.075?

4.—How many fluidounces of alcohols, specific gravity 0.85 and 0.95, must be mixed to make two pints of alcohol having a specific gravity of 0.87?

No dependence can be placed on the results in the case of liquids that contract in volume on being mixed; as the following example will serve to illustrate:

5.—How many mils of alcohol, specific gravity 0.812, and water must be mixed to produce 1000 mils of alcohol having a specific gravity of 0.93?

$$0.93\left|\begin{array}{l|l} 0.812 & 7 \\ 1.000 & 11.8 \end{array}\right.$$

$$\begin{array}{rl} 1000 \div 18.8 = 53.19 & \\ 7 \times 53.19 = 372.33 & \text{mils of alcohol.} \\ 11.8 \times 53.19 = 627.64 & \text{mils of water.} \\ \overline{999.97} & \end{array}$$

According to the above calculation, if 372.33 mils of alcohol are mixed with 627.64 mils of water, 999.97 mils of a mixture having a specific gravity of 0.93 should be produced, but in actual practice it produces 976 mils of a mixture having a specific gravity of 0.953.

In order to produce an alcohol having a specific gravity of 0.93, equal volumes of alcohol and water must be mixed. While the difference in specific gravity may appear but slight, the actual difference in strength of the two mixtures amounts to 12.7 per cent. by volume of alcohol.

ATOMIC AND MOLECULAR WEIGHTS

Elements are made up of infinitesimal particles called atoms. There are as many different kinds of atoms as there are elements. An atom is the smallest particle of an element that can enter into the composition of a molecule. A molecule is the smallest particle into which a substance can be divided without losing its identity. Molecules unite to form matter. If matter has weight it follows that molecules and atoms have weight. The relative weights of these atoms, compared with oxygen 16 as a unit, are their atomic weights.

Symbols are used to represent the elements. Each symbol represents one atom of the element, and as each atom has a definite weight, then each symbol must represent a definite weight of the element. As molecules are made up of atoms, it follows that the molecular weight of a substance must be equal to the sum of the weights of the atoms of which it is composed.

Molecules may contain atoms of like or unlike elements. The molecules of nearly all of the elements contain two atoms; therefore, their molecular weight is twice their atomic weights. The following are the principal exceptions:

Mercury, cadmium, zinc, sodium, and potassium are monatomic; therefore, their molecular weights are the same as their atomic weights. Phosphorus and arsenic are tetratomic; therefore, their molecular weights are four times their atomic weights.

41.—TO FIND THE MOLECULAR WEIGHT OF A SUBSTANCE FROM ITS FORMULA

1.—*Example.*—What is the molecular weight of sodium phosphate? One molecule contains $Na_2HPO_4 + 12H_2O$. The atomic weight of sodium is 23; hydrogen, 1.008; phosphorus, 31.04; oxygen, 16.

2 atoms of Na weigh, $2 \times 23 = 46.$
25 " " H " $25 \times 1.008 = 25.2$
1 " " P " $31.04 = 31.04$
16 " " O " $16 \times 16 = 256.$
$\overline{358.24}$ molecular weight.

For Table of Atomic and Molecular Weights used in this book see pages 92–95.

PROBLEMS

Find the molecular weights of the following:
2.—Sodium nitrate. Ans. 85.01.
3.—Water. Ans. 18.016.
4.—Anhydrous ferrous sulphate.
5.—Crystallized ferrous sulphate.
6.—Potassium bromide.

Atomic weights are relative weights. Therefore, they may be adapted to the use of any system of weights, or weights of any size. In the sodium phosphate already given, the quantities obtained may be used equally well as grams, grains, ounces, or pounds. If grains were taken, then 358.24 grains of sodium phosphate would contain 46 grains of sodium, 25.2 grains of hydrogen, 31.04 grains of phosphorus, and 256 grains of oxygen.

42.—TO FIND THE PERCENTAGE COMPOSITION OF A SUBSTANCE WHEN THE MOLECULAR FORMULA IS GIVEN

1.—*Example.*—What is the percentage composition of nitric acid?

The molecular weight of nitric acid is to the atomic weight of hydrogen as 100 is to the percentage of hydrogen, as shown in the following equation:

$$HNO_3 : H :: 100 : x$$
$$63.02 : 1.008 :: 100 : 1.599 = \% \text{ of H}$$

The molecular weight is to the atomic weight of nitrogen as 100 is to the percentage of nitrogen,

$$HNO_3 : N :: 100 : x$$
$$63.02 : 14.01 :: 100 : 22.23 = \% \text{ of N}$$

As there are three atoms of oxygen in nitric acid, the weight of the combined atoms of oxygen is 48; therefore,

$$\begin{array}{l} HNO_3 : 3 \text{ of } O :: 100 : x \\ 63.02 : \quad 48 \quad :: 100 : 76.166 = \% \text{ of } O \end{array}$$

PROBLEMS

Find the percentage composition of the following:

2.—Benzoic acid, $HC_7H_5O_2$.
Ans. H, 4.955; C, 68.8; O, 26.21 per cent.
3.—Sodium chloride, NaCl. Ans. Na, 39.34; Cl, 60.65.
4.—Alcohol, C_2H_6O. Ans. C, 52.11; H, 13.13; O, 34.73.
5.—Ammonia gas, NH_3. Ans. N, 82.24; H, 17.75.
6.—Zinc sulphate, $ZnSO_4$.
7.—Water, H_2O.
8.—Morphine, $C_{17}H_{29}NO_3$.
9.—Paraldehyde, $C_6H_{12}O_3$.

43.—TO FIND THE PERCENTAGE OF TWO OR MORE ELEMENTS IN A SUBSTANCE WHEN ITS FORMULA IS GIVEN

1.—*Example.*—What per cents. of sulphuric anhydride, SO_3, and barium oxide, BaO, are present in barium sulphate, $BaSO_4$?

Barium sulphate is to barium oxide as 100 is to the per cent. of barium oxide.

$$\begin{array}{l} BaSO_4 : \; BaO \; :: 100 : x \\ 233.44 : 153.37 :: 100 : 65.69, \text{ per cent. of BaO.} \end{array}$$

Barium sulphate is to sulphuric anhydride as 100 is to the per cent. of sulphuric anhydride.

$$\begin{array}{l} BaSO_4 : \; SO_3 :: 100 : x \\ 233.44 : 80.07 :: 100 : 34.3, \text{ per cent. of } SO_3. \end{array}$$

PROBLEMS

2.—What per cent. of water is present in crystallized phosphate of sodium $Na_2HPO_4 + 12H_2O$? Ans. 60.34 per cent.

3.—What per cent. of potassium chloride, KCl, may be obtained from potassium chlorate, $KClO_3$, if the oxygen is driven off by heat? Ans. 60.82 per cent.

4.—Ammonia gas forms what per cent. of ammonium chloride?

5.—What per cent. of crystallized sodium carbonate, $Na_2CO_3 + 10H_2O$, is anhydrous sodium carbonate?

6.—When crystallized ferrous sulphate is heated to 115° C. it loses 6 molecules of water of crystallization. What per cent. is lost?

44.—TO FIND THE WEIGHT OF ONE OR MORE ELEMENTS IN A GIVEN QUANTITY OF SUBSTANCE

1.—*Example.*—How much bromine is there in 12 ounces of potassium bromide?

The molecular weight of potassium bromide is to the atomic weight of the bromine as the given quantity is to the desired quantity.

$$\text{KBr} : \text{Br} :: 12 : x$$
$$119.02 : 79.92 :: 12 : 8.05, \text{ ounces of bromine}$$

PROBLEMS

2.—How many grams of potassium chloride can be obtained from 1000 grams of potassium chlorate? Ans. 608.3 Gm.

3.—How many ounces of exsiccated ferrous sulphate may be manufactured from 25 Av. ounces of crystallized ferrous sulphate, if six molecules of water are removed by heat?
Ans. 15 oz., 106.7 grains.

4.—How many lbs. of carbonic acid gas are lost when 50 lbs. of carbonate of lime are converted into oxide?

5.—When crystallized sodium carbonate is exposed to dry air it loses half of its water of crystallization. How many ounces of effloresced sodium carbonate may be obtained from 5 ounces of the crystallized carbonate?

45.—TO FIND THE AMOUNT OF ONE SUBSTANCE REQUIRED TO UNITE WITH A GIVEN QUANTITY OF ANOTHER

When working problems that involve chemical action, it is advisable to first write an equation that completely expresses the chemical action and the exact amount of each substance represented in the equation. This will prevent overlooking cases where more than one molecule of a substance unites with only one molecule of another. In many cases water is in actual combination with a substance, and must not be neglected when it forms a part of one or both terms of a problem, as in the case of citric acid in the problem given below.

1.—***Example.***—How many grains of citric acid are required to unite with 2 drams of potassium bicarbonate to form potassium citrate?

$$3KHCO_3 + H_3C_6H_5O_7.H_2O = K_3C_6H_5O_7.H_2O + 3H_2O + 3CO_2$$
3×100.11 $\quad$ 210.08

As three molecules of potassium bicarbonate are required to unite with one molecule of citric acid, the number of parts of potassium bicarbonate required to unite with 210.08 parts of citric acid is three times its molecular weight, or 300.33 parts. If 300.33 parts of potassium bicarbonate require 210.08 parts of citric acid, one part or one grain will require $\frac{1}{300.33}$ of 210.08 or 0.6994 of one grain. Then 120 grains will require 120×0.6994, or 83.938 grains of citric acid.

Or, by proportion, 300.33 : 210.08 :: 120 : 83.938 grains of citric acid.

PROBLEMS

2.—How many grams of sodium bicarbonate are required to unite with 600 grams of absolute sulphuric acid?
Ans. 1027.745 grams.

3.—If hydrogen sulphide is passed into a solution containing 50 grams of lead acetate, how many grams of the gas will be consumed in the precipitation of the lead as sulphide? Ans. 4.495 Gm.

4.—Find the number of grains of hydrochloric acid gas that will be required to unite with an Apothecaries' ounce of potassium bicarbonate.

5.—Find the number of grains of salicylic acid which must be mixed with 4 drams of sodium bicarbonate to form sodium salicylate.

6.—Find the number of grams of ammonium carbonate required to combine with 200 grams of citric acid to form ammonium citrate.

7.—How many grams of iodine are required to unite with 60 grams of iron to form ferrous iodide?

8.—How many grams of iron are consumed in the manufacture of ferrous iodide from 75 grams of iodine?

9.—How many grams of potassium iodide are required to unite with 331 grams of mercuric chloride to form mercuric iodide?

10.—How many grams of mercury may be dissolved in strong nitric acid, which contains 25 grams of absolute acid? The solution is to be made without heat.

11.—How many grains of absolute hydrochloric acid are required to dissolve 3 drams of mercuric oxide?

46.—TO FIND THE AMOUNT OF SUBSTANCE REQUIRED TO MAKE A GIVEN QUANTITY OF PRODUCT

1.—*Example.*—How many grams of silver will be required to make 18 grams of silver nitrate?

$AgNO_3 : Ag :: 18 : x$
169.89 : 107.88 :: 18 : 11.43, the amount of silver required.

PROBLEMS

2.—How many ounces of metallic iron, assuming the iron to be pure, will be required to make 32 oz. of crystallized ferrous sulphate? Ans. 6.437 oz.

3.—How many grains of magnesium oxide will be required to make 450 grains of magnesium sulphate? Ans. 73.6 grains.

4.—How many grams of pure metallic zinc must be dissolved in hydrochloric acid to make 1500 grams of zinc chloride?

5.—How many grams of iodine will be consumed in the manufacture of a kilogram of lead iodide?

6.—How many grains of bromine are there in an Apothecaries' ounce of ferrous bromide?

7.—How many grams each, of pure calcium oxide and hydrochloric acid gas, are required to manufacture 500 grams of crystallized calcium chloride?

47.—TO FIND THE AMOUNT OF MATERIAL FORMED FROM A GIVEN QUANTITY OF SUBSTANCE

1.—*Example.*—How many grams of calomel will be formed by treating 100 grams of corrosive sublimate with an excess of mercury?

$HgCl_2 : 2HgCl$
271.52 : 472.12 :: 100 : 173.88 Gm. of $HgCl$.

PROBLEMS

2.—How many grams of mercuric chloride can be formed from 120 grams of mercury? Ans. 162.424 Gm. of $HgCl_2$.

3.—How many grains of barium carbonate will be formed by passing carbon dioxide through a solution containing 1000 grains of barium chloride? Ans. 807.83 gr. of $BaCO_3$.

4.—If a solution containing 500 grams of silver nitrate is precipitated by hydrochloric acid, how much silver chloride will be formed? What quantity of silver does it contain?

5.—If an excess of iron wire is acted upon by 45 grams of iodine, how many grams of ferrous iodide will be formed?

48.—WHEN THE GIVEN QUANTITY IS NOT ABSOLUTE BUT OF A DEFINITE STRENGTH

1.—***Example.***—How many grams of sodium bicarbonate will be required to neutralize 150 grams of hydrochloric acid?

Absolute hydrochloric acid is a gas, and is found in commerce only as a solution of the gas in water, of varying strength. In the problem the strength of the acid is not given; therefore, it must be considered as the strong pharmacopœial acid, which contains 31.9 per cent. by weight of acid. One hundred and fifty grams of hydrochloric acid contain 31.9 per cent. of 150, which is 47.85 Gm. of absolute HCl.

$$HCl : NaHCO_3$$
$$36.47 : 84.01 :: 47.85 : 110.225 \text{ Gm. of } NaHCO_3$$

PROBLEMS

2.—How many grains of barium sulphate will be precipitated by treating 4 Apothecaries' ounces of dilute sulphuric acid with barium chloride? Ans. 466.7 grains.

3.—How many ounces of pure potassium hydroxide may be neutralized by 100 ounces of 10-per cent. nitric acid? Ans. 8.9 oz.

4.—How many grams of magnesium carbonate may be formed from 250 grams of a 30-per cent. solution of magnesium sulphate?

5.—If an excess of zinc is treated with 12 avoirdupois ounces of hydrochloric acid, how many ounces of zinc chloride will be formed?

6.—If 400 grains of sodium carbonate, which contain 75 per cent. of anhydrous sodium carbonate, be treated with salicylic acid, how many grains of sodium salicylate will be formed?

49.—WHEN THE DESIRED QUANTITY IS TO BE OF A CERTAIN STRENGTH

1.—*Example.*—How many grams of 10-per cent. hydrochloric acid will be required to precipitate the silver from a solution containing 12 grams of silver nitrate?

In this case the per cent. does not refer to the substance of which the quantity is given, but to the required substance. The per cent. cannot be taken into consideration until the amount of absolute substance has been obtained. Therefore, in this problem the first step is to find the amount of absolute hydrochloric acid required and then divide by the per cent.

$$\begin{aligned} &AgNO_3 : HCl \\ &169.89 : 36.47 :: 12 : 2.576 = \text{absolute HCl} \\ &2.576 \div 0.10 = 25.76 \end{aligned}$$

PROBLEMS

2.—How many grams of 96-per cent. sulphuric acid will be required to precipitate 725 grams of lead sulphate from a solution of lead acetate?

Ans. 244.302 Gm. of 96-per cent. sulphuric acid.

3.—How many ounces of 25-per cent. nitric acid will be required to neutralize 5 ounces of sodium bicarbonate?

Ans. 15 oz. of 25% HNO_3.

4.—How many grams of 15-per cent. solution of silver nitrate are required to precipitate silver iodide from a solution containing 80 grams of sodium iodide?

5.—How many grams of 32-per cent. hydrochloric acid are required to liberate the carbon dioxide from 1575 grams of a 15-per cent. solution of potassium carbonate?

6.—How many ounces of a solution containing 5 per cent. of barium chloride will be required to precipitate twenty-five ounces of a solution containing 20-per cent. of zinc sulphate?

VOLUMETRIC ANALYSIS

Volumetric analysis is the quantitative estimation of substances by means of solutions of known strength, the quantity of substance being determined by the volume of the standard solution used.

50.—VOLUMETRIC SOLUTIONS

The strengths of volumetric solutions are based upon their combining power, compared with the valency of hydrogen.

$$\begin{array}{cccc} \mathrm{AgNO_3} & +\ \mathrm{HCl} & =\ \mathrm{AgCl} & +\ \mathrm{HNO_3} \\ 169.89 & 36.47 & 143.34 & 63.02 \end{array}$$

Thus, 36.47 parts of hydrochloric acid will unite with 169.89 parts of silver nitrate. Therefore, if 36.47 grams of absolute hydrochloric acid are dissolved in a liter of water, and 169.89 grams of silver nitrate in another liter of water, and the two solutions are mixed, there will be just enough acid to precipitate all the silver. The same will be true if any number of mils of one solution be mixed with an equal number of mils of the other solution. If one liter of a solution contains 36.47 grams of hydrochloric acid, each mil would contain $\frac{36.47}{1000}$ or 0.03647 gram, and would be equivalent to 0.16989 gram of silver nitrate, or, to $\frac{1}{1000}$ of the combining weight, in grams, of any other substance with which it will unite, e. g., 0.05611 gram of potassium hydroxide.

A normal solution is one that contains the combining weight, expressed in grams, of the active reagent in one liter of the solution. The combining weight or valency of a substance must not be confounded with the molecular weight.

The Pharmacopœia defines a normal volumetric solution, N/1, as one that contains in 1 liter the molecular weight of the active reagent, expressed in grams, and reduced to the valency corresponding to one atom of replaceable hydrogen or its equivalent.

Hydrochloric acid contains one atom of replaceable hydrogen. Sodium hydroxide and sodium chloride each contain one atom of sodium capable of replacing one atom of hydrogen. Therefore, their normal solutions should contain respectively, HCl, 36.47 Gm.; NaOH, 40.01 Gm.; and NaCl, 58.46 Gm., in one liter. Sulphuric and oxalic acids each contain 2 atoms of replaceable hydrogen. Therefore, one liter of N/1 H_2SO_4, molecular weight 98.09, should contain 49.045 Gm. One liter of N/1 oxalic acid, $H_2C_2O_4.2H_2O$, mol. wt. 126.05, should contain 63.025 grams. Two molecules of potassium permanganate in oxidation give off 5 atoms of oxygen, which are equivalent to 10 atoms of hydrogen; therefore, one-fifth of one molecule of potassium permanganate represents the number of grams for one liter of normal solution.

$$\frac{KMnO_4}{158.03} \div 5 = 31.606 \text{ Gm.}$$

Decinormal solutions are one-tenth the strength of normal and are expressed as N/10. Centinormal solutions are one-hundredth the strength of normal and expressed as N/100. Semi-normal solutions are one-half the strength of normal and are expressed as N/2. The following strengths are sometimes used: Twice the strength of normal, 2/N; one-twentieth normal, N/20; one-fortieth normal, N/40; one-fiftieth normal, N/50.

The Pharmacopœia gives complete directions for the manufacture of volumetric solutions, and under each a list of articles with the amount of each article that is equivalent to one mil of the volumetric solution.

51.—TO FIND THE FACTOR

Many volumetric solutions change on standing. When this has occurred, instead of bringing them back to their original strength, many prefer to ascertain their strength and make the necessary correction each time they are used.

1.—*Example.*—On exposure to air a decinormal solution of potassium hydroxide has absorbed carbon dioxide until 10.5 mils of the solution are required to neutralize 10 mils of decinormal acid. What correction must be made for each mil of solution used?

$10 \div 10.5 = 0.952$. If 10.5 mils were required instead of 10, then one mil of the solution is equal to $\frac{10}{10.5}$, or, 0.952 mil. Since one mil of the solution is the equivalent of only 0.952 of one mil of a standard solution, then whenever this solution is used, the number of mils of the solution consumed must be multiplied by the factor 0.952.

PROBLEMS

2.—What will be the factor of an acid solution if 10 mils of a standard alkali solution neutralize 9.4 mils of the acid solution?

Ans. 1.064.

3.—What is the factor of sodium thiosulphate solution if 28 mils are required to decolorize 25 mils of standard iodine solution?

Ans. 0.89249.

4.—How many mils of standard sulphuric acid are equivalent to 40 mils of N/10 acid which has a factor of 1.062?

Ans. 42.48 mils.

5.—How many grams of silver nitrate in 25 mils of N/1 solution having a factor of 0.975?

6.—What is the factor for a solution of potassium hydroxide if 55 mils of N/100 are required to neutralize 5 mils of a standard N/10 acid?

7.—How many grams of absolute hydrochloric acid in 45 mils of N/20 acid having a factor of 1.02?

8.—What is the factor for a volumetric solution of potassium hydroxide if 22.6 mils of N/40 are required to neutralize 5 mils of N/10 acid?

52.—ALKALIMETRY

1.—*Example.*—What is the strength of caustic potassa when 0.5 Gm. neutralizes 8 mils of N/1 acid?

Since one mil of normal acid will neutralize 0.05611 Gm. of potassium hydroxide, 8 mils will neutralize 8 times 0.05611 or 0.44888 Gm. If half a gram of caustic potassa contains 0.44888 gram of potassium hydroxide, 100 grams will contain as many times 0.44888 gram as 0.5 is contained times in 100, or $0.44888 \times \frac{100}{0.5} = 89.776$ Gm., or 89.776 per cent.

PROBLEMS

2.—How many grams of potassium hydroxide are there in 800 mils of a solution, when 10 mils of the solution require 25 mils of normal acid to neutralize it? Ans. 112.22 Gm.

3.—What degree of purity has lithium carbonate if 0.5 gram of the dry salt, when dissolved in water, neutralizes 13.5 mils of normal sulphuric acid, using methyl orange as indicator? Ans. 99.738 per cent.

4.—How many pounds of anhydrous sodium carbonate are present in 50 lbs. of commercial washing soda, if two grams, when dissolved in water and titrated, using methyl orange as indicator, require 18 mils of N/1 sulphuric acid for neutralization?

5.—A pharmacist had 100 pounds of commercial sodium carbonate that had previously lost part of its water of crystallization, so that when tested 1 Gm. neutralized 8 mils of N/1 volumetric solution of sulphuric acid. What was its original weight?

6.—How many grams of ammonia gas in 750 mils of ammonia water, if 5 mils require 30 mils of N/1 sulphuric acid for neutralization?

53.—ACIDIMETRY

1.—*Example.*—How many grams of absolute hydrochloric acid are there in 160 grams of acid if 5 grams of the solution require 40 mils of normal potassium hydroxide for neutralization?

Since one mil of normal alkali will neutralize 0.03647 gram of hydrochloric acid, 40 mils will neutralize 40 times 0.03647, or 1.4588 grams of HCl. If 5 grams of the acid contain 1.4588 grams, 160 grams will contain as many times 1.4588 grams as 5 is contained times in 160, or $1.4588 \times \frac{160}{5} = 46.68$ grams of absolute hydrochloric acid.

PROBLEMS

2.—What is the strength of acetic acid when 30 mils of normal potassium hydroxide are required to neutralize 5 grams of the acid?

Ans. 36 per cent.

3.—When 4 grams of acetic acid neutralize 40 mils of decinormal potassium hydroxide solution, what is the strength of the acid?

Ans. 6 per cent.

4.—How many mils of decinormal sulphuric acid are required to neutralize 50 grams of a 5-per cent. solution of potassium hydroxide?

5.—How many grams of acid in 500 mils of commercial hydrochloric acid if 2 mils neutralize 17 mils of normal potassium hydroxide solution, factor 0.952?

6.—If 5 grams of aromatic sulphuric acid are mixed with water and boiled thoroughly, and when cold require 20 mils of normal potassium hydroxide for neutralization, what is the strength of the acid?

7.—Forty mils of normal potassium hydroxide are required to neutralize 3 grams of tartaric acid. What is the strength of the acid?

54.—SILVER NITRATE VOLUMETRIC SOLUTION

PROBLEMS

1.—What per cent. of potassium iodide is present in commercial potassium iodide, when 0.5 Gm. requires 29.8 mils of N/10 silver nitrate solution to produce a permanent red color when tested according to the Pharmacopœia?

$$KI + AgNO_3 = AgI + KNO_3$$

Ans. 98.947 per cent.

2.—What is the strength of diluted hydrobromic acid, when 1 Gm. requires 12 mils of N/10 silver nitrate to produce a permanent red tint with potassium chromate as indicator?

Ans. 9.71 per cent.

3.—What is the strength of potassium cyanide when 0.5 Gm. of the commercial salt requires 70 mils of N/10 silver nitrate solution for complete precipitation?

4.—How many grams of pure potassium cyanide are there in 50 grams of the commercial salt if 1 gram requires 69 mils of decinormal silver nitrate to produce a faint, permanent precipitate, when tested according to the Pharmacopœia?

Ans. 44.926 Gm.

Note.—As the double cyanide of potassium and silver is formed, one molecule of silver nitrate is equivalent to two molecules of potassium cyanide. Therefore, one mil of decinormal silver nitrate is equivalent to 0.01293 Gm. of potassium cyanide. Had the silver solution been added to complete precipitation it would have required 138 mils, for the double salt would have been broken up and silver cyanide formed as in the third problem. Thus:

$$2KCN + AgNO_3 = KAg(CN)_2 + KNO_3$$
$$KAg(CN)_2 + AgNO_3 = 2AgCN + KNO_3$$

5.—What is the strength of dilute hydrocyanic acid if 2 mils require 14.2 mils of decinormal silver nitrate for complete precipitation?

6.—What per cent. of hydrocyanic acid is present in fl. ext. of wild-cherry bark, when the distillate from 10 mils is carried into 10 mils of decinormal silver nitrate solution and 6.5 mils of decinormal potassium sulphocyanide solution are required to precipitate the excess of silver nitrate?

Note.—Volumetric solution of potassium sulphocyanide is only used in residual titration as in above problem. The silver nitrate must be present in excess, and a few drops of a solution of ferric nitrate added, then the excess of silver nitrate determined by adding the solution of sulphocyanide until a permanent reddish-brown tint is produced. Each mil of the sulphocyanide is equivalent to one mil of the silver nitrate solution.

7.—How many grains of ferrous iodide in one avoirdupois pound of syrup of iodide of iron if 1.536 grams of the syrup, when tested according to the Pharmacopœia, using 6 mils of decinormal silver nitrate solution, require 0.5 mil of decinormal sulphocyanide solution to produce a reddish-brown tint? Also, how many grains of syrup must be added to reduce it to the Pharmacopœial strength?

55.—IODINE VOLUMETRIC SOLUTION

PROBLEMS

1.—If one gram of commercial sodium sulphite be added to 80 mils of decinormal iodine solution and 5 mils of N/10 sodium thiosulphate solution be required to discharge the color, what per cent. of pure sodium sulphite is present? Ans. 94.56 per cent.

$$\frac{Na_2SO_3.7H_2O}{252.18} + 2I + 4H_2O = Na_2SO_4.10H_2O + 2HI.$$

Note.—As each molecule of sodium sulphite requires two molecules of iodine, each mil of decinormal solution of iodine is equivalent to 0.012609 gram of sodium sulphite.

2.—If 0.1 gram of arsenic trioxide decolorizes 19.5 mils of decinormal iodine solution, what per cent. of pure arsenic trioxide is present?

$$As_2O_3 + 4NaHCO_3 + 4I = As_2O_5 + 4NaI + 4CO_2 + 2H_2O.$$

3.—What per cent. of sulphur dioxide is present in a solution of sulphurous acid, when 2 Gm. diluted with water decolorize 38 mils of N/10 iodine solution?

4.—What is the strength of a solution of sodium thiosulphate when 10 mils of the solution, containing a few drops of starch paste, require 45 mils of N/10 iodine solution to produce a permanent blue color?

5.—How many grams of arsenic trioxide are present in 1000 mils of a solution, if 5 mils of the solution, when boiled with a mixture of sodium carbonate, a little starch and sufficient water to make 100 mils, followed by cooling, require 25 mils of N/10 iodine solution to produce a permanent blue color?

56.—SODIUM THIOSULPHATE VOLUMETRIC SOLUTION

PROBLEMS

1.—If 0.5 Gm. of iodine requires 39 mils of decinormal sodium thiosulphate solution to decolorize the iodine, what is the per cent. of pure iodine? Ans. 98.99 per cent.

2.—How many grams of iodine are present in 100 mils of tincture of iodine, if 6 mils require 32 mils of N/10 sodium thiosulphate solution to decolorize it?

3.—If 0.5 gram of chlorinated lime requires 35.7 mils of decinormal sodium thiosulphate solution to decolorize the iodine liberated from potassium iodide by the chlorine, what is the per cent. of available chlorine?

Note.—This estimation is based on the fact that one atom of free chlorine liberates one atom of iodine from one of its salts.

4.—If twenty-three mils of N/10 sodium thiosulphate solution are required to decolorize the iodine liberated from potassium iodide by 20 grams of chlorine water, what is the per cent. of free chlorine?

5.—If one gram of solution of iron tersulphate, when tested according to the Pharmacopœia, requires 14.2 mils of decinormal sodium thiosulphate to decolorize the iodine liberated, what is the per cent. of iron in the solution?

Note.—Two atoms of iodine are liberated in the reduction of two atoms of iron from the ferric to the ferrous condition, hence one mil of decinormal iodine is equivalent to 0.005584 gram of iron.

6.—Fifteen mils of decinormal sodium thiosulphate are required to decolorize the iodine liberated when potassium iodide is treated with 0.5 Gm. of iron citrate as directed in the quantitative test for iron citrate. What per cent. of iron is present in the citrate?

57.—POTASSIUM PERMANGANATE VOLUMETRIC SOLUTION PROBLEMS

1.—If one gram of commercial ferrous sulphate requires 30 mils of potassium permanganate solution to produce a pink tint, what per cent. of crystallized ferrous sulphate is present?

Ans. 83.28 per cent.

Note.—Ten molecules of ferrous sulphate have been oxidized to ferric by two molecules of potassium permanganate; hence, one-fifth of a molecule of potassium permanganate is equivalent to one molecule of ferrous sulphate.

2.—How many grams of ferrous carbonate are there in 4 avoirdupois ounces of the saccharated ferrous carbonate, if two grams require 26 mils of decinormal potassium permanganate to produce a pink color?

Note.—The reaction is the same as in the last except that the sulphuric acid first converts the carbonate into a sulphate.

3.—How many grams of pure potassium hypophosphite are there in 150 Gm. of the commercial salt, if three cubic centimeters of decinormal oxalic acid are required to destroy the pink color left after treating 0.1 Gm. of the salt with 40 mils of decinormal potassium permanganate solution?

$$5KH_2PO_2 + 4KMnO_4 + 6H_2SO_4 = 5KH_2PO_4 + 2K_2SO_4 + 4MnSO_4 + 6H_2O.$$

Note.—As each mil of the oxalic acid solution is equivalent to one mil of the potassium permanganate solution, 37 mils of the permanganate solution will be consumed in the oxidation of the hypophosphite.

4.—How many grams of hydrogen peroxide are there in 200 mils of hydrogen peroxide solution, if 1 mil decolorizes 20 mils of decinormal permanganate solution?

58.—ALKALOIDAL ESTIMATIONS

The volumetric estimation of alkaloids is based upon the fact that they unite with acids to form salts, and thus neutralize definite amounts of acids. The alkaloid is obtained as pure as possible and dissolved in an excess of standard acid, and the excess of acid determined by titration with a standard alkali, using hematoxylin, cochineal, or iodeosin as indicator. The difference between the standard acid taken and the standard alkali used represents the amount of acid combined with the alkaloid. Most alkaloids that are estimated volumetrically are monobasic; therefore, 1 mil of decinormal acid is equivalent to 0.0001 of the molecular weight of the alkaloid expressed in grams. In case the alkaloid is dibasic the molecular weight should be divided by two and then by 0.0001 to obtain the equivalent of one mil of acid.

1.—*Example.*—If the morphine from 2 grams of opium is dissolved in 12 mils of decinormal acid, and 29 mils of centinormal alkali are required to neutralize the excess of acid, what is the per cent. of morphine in the opium?

Twenty-nine mils of N/100 alkali will neutralize 2.9 mils of N/10 acid. Subtracting 2.9 mils from 12 mils of acid taken will leave 9.1 mils as the amount of acid combined with the morphine. The molecular weight of morphine is 303.18; therefore, 1 mil of acid is equivalent to 0.030318 Gm. of morphine, and 9.1 mils is equivalent to 0.27589 Gm., the amount from 2 Gm. of opium, which, multiplied by 50, will give the per cent., or 13.79 per cent.

PROBLEMS

2.—The morphine from one gram of opium was dissolved in 5 mils of decinormal acid, and required 2 mils of centinormal alkali to neutralize the excess of acid; what is the per cent. of morphine in the opium? Ans. 14.55 per cent.

3.—What is the purity of morphine if 0.1 Gm. when dissolved in 5 mils of N/10 acid required 7.2 mils of N/40 alkali to neutralize the excess of acid? Ans. 97.01 per cent.

4.—What is the per cent. of alkaloid in belladonna root when the alkaloid from 10 Gm. is dissolved in 3 mils of N/10 sulphuric acid, and requires 5.5 mils of N/50 potassium hydroxide to neutralize the excess of acid?

Note.—The molecular weights of the alkaloids of belladonna and stramonium are 289.2.

5.—If the alkaloids from 10 grams of stramonium leaves are dissolved in 2 mils of acid, N/10, and 11 mils of N/100 alkali are required to neutralize the excess of acid, what is the per cent. of alkaloid?

6.—Ten grams of coca are macerated in an alkaline mixture containing 100 mils of a mixture of chloroform and ether. The alkaloid is removed from 50 mils of the chloroform-ether solution and dissolved in 5.5 mils of decinormal acid, and it requires 44.4 mils of centinormal alkali to neutralize the excess of acid. What is the per cent. of cocaine?

7.—The impure morphine from 20 mils of tincture of opium weighed 0.28 gram. One hundred milligrams of the morphine were dissolved in 5 mils of N/10 acid and 6.8 mils of N/40 alkali were required to neutralize the excess of acid. How many grams of morphine are there in 100 mils of tincture?

8.—Opium containing 30 per cent. of moisture is dried, and the morphine from 2 grams of the powder combined with 9.8 mils of decinormal acid. What per cent. of morphine did the original moist opium contain?

MEASUREMENTS OF GASES

59.—GASES IN GENERAL

Substances existing in the gaseous state are often measured and referred to by volume. Important problems arise as to the volume occupied by a given weight of gas, or the weight of a given volume of gas. Thus it becomes necessary to understand the relation existing between the volume and weight of gases.

The comparative weight of equal volumes of different substances is known as specific gravity. We have seen that, for solids and liquids, water is taken as the unit of comparison. For gases, air, oxygen or hydrogen serves the same purpose.

The volume of all gases varies under different conditions of temperature and pressure. A gas is said to be normal when the temperature is 0° C., and the atmospheric pressure is 760 millimeters. In all calculations a gas is considered as normal unless otherwise stated.

The weight of a liter of air is 1.294 grams, oxygen 1.429 grams, and hydrogen 0.0897 grams.

SPECIFIC GRAVITY OF GASES

60.—TO FIND THE SPECIFIC GRAVITY OF GASES AS COMPARED WITH AIR

1.—*Example.*—One liter of sulphureted hydrogen weighs 1.52 grams. What is its specific gravity?

The weight of a liter of air is 1.294 Gm. $1.52 \div 1.294 = 1.1746$, the Sp. Gr.

PROBLEMS

2.—A cylinder holds 142.065 grams of air and 313.022 grams of sulphur dioxide. What is the specific gravity of the latter?

Ans. 2.203 Sp. Gr.

3.—Twelve liters of ammonia gas weigh 9.13 grams. What is the Sp. Gr. of the ammonia?

4.—What is the specific gravity of nitrogen, if one liter weighs 1.252 grams?

5.—What is the specific gravity of chlorine, if two liters of the gas weigh 6.3239 grams?

61.—TO CHANGE THE SPECIFIC GRAVITY OF GASES FROM AIR AS UNIT TO HYDROGEN AS UNIT

1.—*Example.*—The specific gravity of nitrous oxide gas as compared with air is 1.52. What is its specific gravity as compared with hydrogen.

Since air is 14.4 heavier than hydrogen, the specific gravity of any gas as compared with hydrogen must be 14.4 greater than the specific gravity when compared with air.

$$1.52 \times 14.4 = 21.888.$$

PROBLEMS

The specific gravities of the following gases were obtained with air as unit. What are their specific gravities with hydrogen as unit? H = 1

2.—Nitric oxide, 1.0344 Sp. Gr. Ans. 14.895 Sp. Gr.

3.—Hydrofluoric acid, 0.6905 Sp. Gr.

4.—Sulphur dioxide, 2.206 Sp. Gr.

5.—Ozone, 1.6535 Sp. Gr.

62.—TO CHANGE THE SPECIFIC GRAVITY OF GASES FROM AIR AS UNIT TO OXYGEN AS UNIT

Multiply the specific gravity with air as unit by 0.876. The product will be the specific gravity of the gas compared with oxygen as unit.

PROBLEMS

If the specific gravities of the following gases are those with air as the unit, what will be their specific gravities with oxygen as unit?

1.—Methane, Sp. Gr., 0.551.

2.—Carbon dioxide, Sp. Gr., 1.515.

3.—Ethyl nitrate, Sp. Gr., 2.585.

63.—TO FIND THE SPECIFIC GRAVITY OF GASES WITH HYDROGEN AS UNIT

One liter of hydrogen weighs 0.08987 grams and is called a Crith.

1.—*Example.*—One liter of oxygen weighs 1.429 Gm. What is its specific gravity?

$$1.429 \div 0.08987 = 15.89 \text{ Sp. Gr. of oxygen.}$$

PROBLEMS

2.—What is the specific gravity of ammonia gas, one liter of which weighs 0.7608 gram? Ans. 8.468 Sp. Gr.

3.—Ten liters of the vapors of iodine weigh 113.15 grams. What is its specific gravity?

4.—Five liters of nitrous oxide gas weigh 9.828 grams. What is its specific gravity?

5.—What is the specific gravity of methane, if four liters weigh 2.858 grams?

64.—TO CHANGE THE SPECIFIC GRAVITY OF GASES FROM HYDROGEN AS UNIT TO AIR AS UNIT

1.—*Example.*—What is the specific gravity of ammonia gas compared with air? Ans. 0.587 Sp. Gr.

Its specific gravity compared with hydrogen is 8.464. As this is the opposite of section 61, we divide by 14.4 or multiply by its reciprocal, which is 0.0694.

PROBLEMS

The specific gravities of the following gases are given with hydrogen as unit. What are their specific gravities with air as unit?

Air = 1

2.—Arsine, 38.725. Ans. 2.689 Sp. Gr.
3.—Methane, 7.95.
4.—Carbon dioxide, 21.83.
5.—Ethyl nitrite, 37.245.

65.—TO CHANGE THE SPECIFIC GRAVITY OF GASES FROM HYDROGEN AS UNIT TO OXYGEN AS UNIT

Divide the specific gravity with hydrogen as unit by 15.88. The quotient will be the specific gravity of the gas compared with oxygen as unit.

PROBLEMS

Change the following specific gravities with hydrogen as unit to specific gravities with oxygen as unit.

1.—Ammonia gas, Sp. Gr., 8.465.
2.—Chlorine, Sp. Gr., 35.18.
3.—Sulphur dioxide, Sp. Gr., 31.795.
4.—Carbon dioxide, Sp. Gr., 21.74.

66.—TO FIND THE SPECIFIC GRAVITY OF GASES WITH OXYGEN AS UNIT

Divide the weight of a given volume of the gas by the weight of an equal volume of oxygen, or divide the weight of a liter of the gas by the weight of a liter of oxygen, which is 1.429.

PROBLEMS

1.—The weight of a liter of nitrogen is 1.247 Gm. What is its specific gravity compared with oxygen?

2.—The weight of three liters of ethyl nitrite gas is 10.04 Gm. What is its specific gravity?

3.—Methane is 7.95 times heavier than hydrogen. What is its specific gravity compared with oxygen?

4.—A liter of nitric oxide weighs 1.349 Gm. What is its specific gravity?

67.—TO CHANGE THE SPECIFIC GRAVITY OF GASES FROM OXYGEN AS UNIT TO HYDROGEN AS UNIT

Multiply the specific gravity with oxygen as unit by 15.88. The product will be the specific gravity of the gas compared with hydrogen as unit.

PROBLEMS

The following specific gravities are with oxygen as unit. What will be their specific gravities with hydrogen as unit?

1.—Chlorine, Sp. Gr., 2.216.
2.—Hydrogen sulphide, Sp. Gr., 1.062.
3.—Ozone, Sp. Gr., 1.5.

68.—TO CHANGE THE SPECIFIC GRAVITY OF GASES FROM OXYGEN AS UNIT TO AIR AS UNIT

Multiply the specific gravity with oxygen as unit by 1.14. The product will be the specific gravity with air as unit.

PROBLEMS

The specific gravities of the following gases are with oxygen as unit. What will be their specific gravities with air as unit?

1.—Arsine, Sp. Gr., 2.436.
2.—Phosphine, Sp. Gr., 1.063.
3.—Hydrochloric acid gas, Sp. Gr., 1.14.

69.—THE RELATION OF MOLECULAR WEIGHT TO SPECIFIC GRAVITY AS COMPARED WITH OXYGEN

As all molecules of gases are of the same volume, under like conditions of temperature and pressure, and molecular weights of gases are the relative weights of equal volumes compared with oxygen, it follows that the ratio of the molecular weights of two gases is the same as the ratio of their specific gravities.

$$\begin{array}{ccccccc} \text{Mol. wt.} & & \text{Mol. wt.} & & \text{Sp. Gr.} & & \text{Sp. Gr.} \\ \text{of } CO_2 & : & \text{of } NO_2 & :: & \text{of } CO_2 & : & \text{of } NO_2 \\ 44 & : & 46.02 & :: & 1.375 & : & 1.438 \end{array}$$

Therefore the molecular weight of oxygen is to the molecular weight of a gas as 1 is to the specific gravity of the gas. Hence, to find the specific gravity of a gas from its molecular weight, divide its molecular weight by 32, the molecular weight of oxygen. The product will be its specific gravity.

The molecular weight of carbon dioxide is 44, which divided by 32 gives 1.375 as its specific gravity.

PROBLEMS

Find the specific gravities of the following from their molecular weights:

2.—Nitrogen.

3.—Ammonia gas.
4.—Ethyl nitrite.
5.—Chlorine.
6.—Sulphur dioxide.
7.—Nitrous oxide.

70.—TO FIND THE WEIGHT OF A GIVEN VOLUME OF GAS

In the following problems in this work oxygen will be understood as the standard unit unless otherwise stated.

1.—*Example.*—What is the weight of 25 liters of chlorine?

Since the weight of a liter of oxygen is 1.429 grams the weight of a given volume of any gas may be found by multiplying 1.429 by the specific gravity of the gas, and by its volume,

$$1.429 \times 2.216 \times 25 = 79.16.$$

PROBLEMS

2.—How many grams in 450 liters of sulphur dioxide?

3.—If the specific gravity of bromine vapor is 79.34, what will 75 liters weigh?

4.—How many grams of arsine are required to fill a five-liter flask?

5.—How many grams of nitrous oxide gas are required to fill a 10-gallon cylinder?

6.—How many grams of nitrous oxide gas are required to fill a 25-liter cylinder? Sp. Gr. of N_2O is 1.518 when air = 1.

71.—TO FIND THE VOLUME OF A GIVEN WEIGHT OF GAS

1.—*Example.*—What is the volume of 79.5 grams of chlorine?

$$\frac{79.5}{1.429 \times 2.216} = 25.11 \text{ liters.}$$

PROBLEMS

2.—How large a flask will be required to hold 30 grams of sulphur dioxide.

3.—How many liters in 480 grams of oxygen?

4.—How many liters must a tank contain in order to hold 50 grams of sulphuretted hydrogen?

5.—How many liters of oxygen can be obtained from 100 grams of potassium chlorate?

6.—How many liters of carbon dioxide can be liberated from 150 grams of calcium carbonate?

7.—How many liters of hydrogen will be consumed in the manufacture of reduced iron from 5 grams of ferric oxide?

72.—TO FIND THE SPECIFIC GRAVITY OF A MIXTURE OF GASES WHEN THE COMPOSITION AND QUANTITY OF EACH ARE KNOWN

1.—***Example.***—If two liters of oxygen are mixed with eight liters of nitrogen, what is the specific gravity of the mixture?

From the molecular formula of each we find the specific gravity; then multiply the specific gravity of each by its volume. The sum of the products divided by the total volume of the mixture will give the specific gravity of the mixture.

PROBLEMS

2.—What is the specific gravity of a mixture containing 2 volumes of carbon dioxide, 3 volumes of oxygen, and 12 volumes of nitrogen?

3.—What is the specific gravity of a mixture of 4 pints of nitrous oxide (N_2O) and one pint of nitric oxide (NO)?

4.—If two liters of nitrous oxide are mixed with 5 liters of air, what will be the specific gravity of the mixture?

5.—One liter of air, 500 mils of hydrogen, 250 mils of carbon dioxide, and 125 mils of arsine are mixed. What is the specific gravity of the mixture?

6.—Four volumes of ammonia gas and three volumes of hydrogen are mixed with two volumes of air. What is the resulting specific gravity?

73.—SPECIFIC VOLUME OF GASES

Specific volume of gases is the relative volume of equal weights of different gases. Specific volume is usually expressed in terms of mils, and may be defined as the number of mils occupied by one gram of gas. Hence the specific volume of hydrogen is $\frac{1}{0.00008987} = 11126$ mils. The specific volume of air is $\frac{1}{0.001294} = 772.72$ mils.

PROBLEMS

What is the specific volume of the following:

1.—Hydrochloric acid?

2.—Chlorine?

3.—Sulphur dioxide?

4.—Oxygen?

5.—Nitric oxide (NO)?

6.—Methane (CH_4)?

74.—GRAM-MOLECULE

A gram-molecule is the number of liters occupied by the molecular weight, in grams, of a gas. *The normal volume is 22.39 liters and is the same for all gases under like conditions.* The molecular weight of hydrogen is two. Hence, 2 divided by the weight of a liter of hydrogen (0.08987) gives the number of liters occupied by the molecular weight expressed in grams. The molecular weight of carbon dioxide is 44. Hence 44 grams of CO_2 will measure 22.39 liters. The molecular weight of chlorine is 70.92, and 70.92 grams of Cl measure 22.39 liters. The gram-molecule is sometimes used in the calculation of gaseous volumes, but the methods given in sections 70 and 71 are preferred by many.

75.—TO FIND THE WEIGHT OF A GIVEN VOLUME OF GAS, USING THE GRAM-MOLECULE

Example.—How many grams in 25 liters of chlorine?

The number of gram-molecules may be found by dividing 25 by 22.39, which gives 1.1165; this multiplied by 70.92, the molecular weight of chlorine, gives 79.18218 as the number of grams in 25 liters.

PROBLEMS

Work those given under section 70, using the gram-molecule.

76.—TO FIND THE VOLUME OF A GIVEN WEIGHT OF GAS, USING THE GRAM-MOLECULE

Example.—How many liters in 212.76 grams of chlorine?

The weight of a gram-molecule of chlorine is 70.92 Gm. By dividing 212.76 by 70.92 we have 3 as the number of gram-molecules in 212.76 Gm. of chlorine. Three times 22.39, or 67.17 liters, is the volume of the chlorine.

PROBLEMS

Solve those given under section 71, using the gram-molecule.

VOLUMETRIC COMBINATION AND DECOMPOSITION OF GASES

77.—TO FIND THE VOLUME OF A GAS THAT WILL UNITE WITH A GIVEN VOLUME OF ANOTHER GAS

1.—*Example.*—How many liters of hydrogen will be required to unite with 5 liters of oxygen?

One molecule or one volume of oxygen unites with two molecules or two volumes of hydrogen. Therefore, 5 liters of oxygen will unite with 10 liters of hydrogen.

PROBLEMS

2.—How many liters of arsine can be produced by combining four liters of hydrogen with arsenic. Ans. 1.333 liters.

3.—If 25 liters of air contain four-fifths nitrogen and it could all be converted into ammonia gas, how many liters would be formed?

4.—How many liters of water vapor will be formed in the manufacture of reduced iron from 5 liters of hydrogen and ferric oxide?

5.—How many liters of hydrogen are required to manufacture a kiloliter of phosphine?

6.—How many pints of hydrogen and oxygen will unite in order to form 5 gallons of vapor of water?

7.—How many pints of oxygen will be consumed by burning sulphur to form a gallon of sulphur dioxide, and how many grains of sulphur will be consumed?

8.—How many liters of hydrogen and chlorine must be united to form 15 liters of hydrochloric acid gas?

78.—THE EFFECT OF TEMPERATURE AND PRESSURE UPON THE VOLUME OF GASES

In many operations gases must be measured at ordinary working temperature and pressure, and, as the volume of a gas varies with each variation of temperature or pressure, a correction must be made for both before we can ascertain its normal volume or its exact weight.

The volume of a gas or vapor is proportional to the pressure it sustains, if the temperature remains the same.

Boyle's Law.—If the pressure is doubled, the volume of the gas will be diminished one-half. If the pressure be diminished one-half, the volume will be doubled. The product obtained by multiplying the volume of the gas by its pressure is always the same regardless of the pressure it sustains. For example, 50 liters of gas are measured at 600 millimeters pressure; $50 \times 600 = 30000$. Increase the pressure to 1200 millimeters and the volume is decreased to 25 liters; $25 \times 1200 = 30000$. This being true if the volume and pressure of a gas be given and the pressure be increased or diminished, and either the pressure or volume given, the other may be found.

79.—CORRECTION IN VOLUME OF GASES FOR CHANGE IN PRESSURE

1.—*Example.*—If 30 liters of gas were measured at 400 millimeters pressure and the pressure increased to 800 millimeters, what would be its volume? Thirty multiplied by 400 and divided by 800 gives 15 as the volume of the gas.

2.—The volume of gas is 90 liters at 750 millimeters pressure. What will be its volume at 1000 millimeters pressure?

$$750 \times 90 = 67500; \ \frac{67500}{1000} = 67.5 \text{ liters.}$$

3.—What will be the volume of 25 liters of oxygen at normal pressure, when submitted to 850 millimeters pressure?

Ans. 22.25 liters.

4.—At 900 millimeters pressure a volume of gas is 125 liters. What pressure will be required to increase its volume to 150 liters?

5.—What will be the volume of a gas at 1250 mm. pressure if its volume is 200 liters at 850 mm. pressure?

6.—Five volumes of sulphur dioxide are measured at 750 millimeters pressure. What will be its volume at 900 millimeters pressure?

7.—One hundred mils of nitrous oxide gas are measured at 780 millimeters pressure. How many mils will it occupy at normal pressure?

8.—What will be the weight of 1000 mils of oxygen at a pressure of 900 millimeters?

9.—What will be the volume of 10 grams of sulphur dioxide at a pressure of 500 millimeters?

10.—How many grams of potassium chlorate will be required to fill a 10-gallon tank with oxygen at a pressure of 735 millimeters?

80.—CORRECTION IN VOLUME OF GASES FOR CHANGES IN TEMPERATURE

All gases expand and contract equally for each degree of change in temperature, the pressure remaining constant.

Charles' Law.—If 273 volumes of gas at 0° C. are heated they increase one volume for each degree. At 10° it will have increased 10 volumes and have become 283 volumes. The same volume when decreased in temperature from 0° C. to —25° C. will have decreased 25 volumes and have become 248 volumes. If 273 volumes increase or decrease one volume for each degree of change in temperature, then one volume will increase or decrease $\frac{1}{273}$ of its volume for each degree of change in temperature. Expressed decimally this equals 0.003663 of a volume.

1.—*Example.*—If 500 mils of gas are measured at 15° C. and then heated to 25° C., what is its volume?

Since 273 volumes, when raised to 15° C. become 288 volumes, and the same volume when raised to 25° C. has become 298 volumes, and if 288 volumes have increased to 298 volumes in passing from 15° C. to 25° C., then one volume will have increased to $\frac{298}{288} = 1.03472$ volumes. If one volume increases to 1.03472 volumes, 500 volumes will increase to $500 \times 1.03472 = 517.36$ volumes. Hence we have

$$\frac{273 + 25}{273 + 15} \times 500 = 517.36.$$

PROBLEMS

2.—If 500 volumes of gas are measured at 0° C., what will be its volume at 25° C.? Ans. 545.75 volumes.

3.—Two hundred and fifty mils of oxygen are measured at 15° C. and raised to 35° C.; what will be its volume?

Ans. 267.25 mils.

4.—If 1000 mils of gas are measured at 40° C. and the temperature reduced to 10°C., what will be its volume?

Ans. 904.1 mils.

5.—A gas measures 10 liters at 40° C.; what will be its volume at 0° C.?

6.—What will be the volume of a gas at —12° C. if it measures 125 volumes at —8° C.?

7.—What will be the volume of a gas at —15° C. if it measures 250 volumes at 20° C.?

8.—If one volume of gas is measured at —10° C. what will be its volume at 25° C.?

81.—CORRECTION IN VOLUME OF GASES FOR CHANGES IN TEMPERATURE AND PRESSURE

1.—*Example.*—If 250 mils of oxygen are measured at 10° C. and 760 millimeters pressure, what will be its volume at 30° C. and 775 millimeters pressure?

As we have to correct for both temperature and pressure, we must necessarily combine sections 79 and 80.

$$\frac{250 \times 760 \times (273 + 30)}{775 \times (273 + 10)} = \frac{250 \times 760 \times 303}{775 \times 283} = 262.498 \text{ mils}$$

PROBLEMS

2.—What will be the volume of a gas at normal pressure and temperature which measured 750 mils at 16° C. and 725 millimeters pressure? Ans. 675.8 mils.

3.—If spirit of nitrous ether, when tested at 20° C. and 740 millimeters pressure, yields 50 mils of nitric oxide gas, how many mils of gas would have been produced had the test been made at 25° C. and normal pressure? Ans. 49.45 mils.

4.—Twenty volumes of carbon dioxide, at normal temperature and pressure, are heated to 200° C. at a pressure of 850 millimeters. What is its volume?

5.—If air is measured at 25° C. and normal pressure what will be its volume when submitted to a pressure of 1500 millimeters and a temperature of —17° C.?

6.—If 4455 mils of vapor are measured at normal pressure and temperature of 27° C., what will be its volume at 15° C. and 745 millimeters pressure?

82.—TO FIND THE VOLUME OF A CYLINDRICAL VESSEL

1.—***Example.***—How many cubic inches in a vessel six inches in diameter and ten inches high?

Since the radius is half the diameter, or 3, the square of the radius is 9, which multiplied by 3.1416 gives the area of the base, and this multiplied by the altitude, 10, gives the volume of the vessel, or 282.744 cubic inches.

PROBLEMS

2.—How many cubic inches in a can five inches in diameter and nine inches high? Ans. 176.71 cu. in.

3.—How many liters in a bottle 160 millimeters in diameter and 3 decimeters high? Ans. 6.03 liters.

4.—How many gallons in a tank 5 feet high and 2 feet 6 inches in diameter?

5.—How many pounds of mercury will a cylinder hold if its inner measure is 4 inches in diameter and 10 inches high?

6.—How many pounds of glycerin will a can hold that is 18 inches high and 9 inches in diameter?

83.—TO FIND THE VOLUME OF A CONE

1.—*Example.*—What will be the capacity, in mils, of a cone whose base is 16 centimeters in diameter and its altitude 30 centimeters?

The area of the base is found, as in section 82, to be 201.0624 square centimeters. If we multiply this by one-third the altitude we have 2010.624 mils as the contents of the cone.

PROBLEMS

2.—How many mils will a funnel hold that is 13.75 centimeters deep and 15 centimeters in diameter? Ans. 809.94 mils.

3.—How many cubic inches in a hopper if the top is 16 inches in diameter and the depth 22 inches? Ans. 1474.4576 cu. in.

4.—How many fluidounces in a cone-shaped can, if the diameter of the base is 8 inches and the altitude 15 inches?

5.—How many fluidounces will a can hold if the diameter is 8 inches and the total height 18 inches, the cone-shaped top one third of the height?

6.—What is the capacity of a can whose diameter is 7 inches and the altitude of the cylinder 8½ inches and that of the cone one and a half inches?

7.—What is the capacity of a folded filter if the diameter of the filter is 25 centimeters?

MISCELLANEOUS PROBLEMS

84.—MISCELLANEOUS PROBLEMS

1.—In what proportion must 25%, 38% and 92% alcohols be mixed to produce 45% alcohol?

2.—How many grains of cocaine hydrochloride will be required to make 2 fluidounces of a 4% solution?

3.—How many grains of mercuric chloride will be required to make a gallon of solution containing 1 to 10,000?

4.—How many fluidounces of glycerin in 10 pounds of solution containing 30% of glycerin?

5.—What is the volume capacity of a can which holds 25 lbs. of ether?

6.—When 100 grains of a substance are placed in a counterpoised bottle and filled with water, the whole weighs 1088 grains. The capacity of the bottle is 1000 grains of water. What is the specific gravity of the substance?

7.—One pound of shot is put into a bottle and filled with water. The total weight is 25,566 grains. The bottle filled with water weighs 19,174 grains. What is the specific gravity of the shot?

8.—A piece of potassium dichromate weighs 120 grams in air and 64 grams in alcohol. What is the specific gravity of the potassium dichromate?

9.—What is the specific gravity of a piece of metal which is 3 dm. long, 12.5 cm. wide and 8 cm. thick and weighs 23,400 grams?

10.—If vanilla costs nine dollars a pound, sugar seven cents a pound and alcohol two dollars and fifty cents a gallon, what will five gallons of tincture of vanilla cost?

11.—What is the strength of a solution of sodium hydroxide which requires 15 mils of normal sulphuric acid solution to neutralize 12 grams of the solution?

12.—If silver nitrate is pure, how many grams of sodium chloride will be required to precipitate all of the silver from 15 grams of silver nitrate?

13.—How many fluidounces of chloroform will be displaced by two pounds of mercury?

14.—How many grains of sodium bicarbonate will be required to neutralize a fluid ounce of official hydrochloric acid, and how much sodium chloride will be formed?

15.—If ether costs 30 cents a pound and chloroform costs 42 cents, what will be the cost of 2 pints of a mixture having a specific gravity of 1.10, no allowance for contraction? 47 3

16.—If ether costs 30 cents a pound and has a specific gravity of 0.716, what will one pint cost?

17.—What will a gallon of glycerin cost at 25 cents a pound?

18.—In what proportion must ether and chloroform be mixed to make a mixture having a specific gravity of 0.876, no allowance for contraction?

19.—How many fluidounces each of ether and chloroform must be mixed to produce one pint of a mixture having a specific gravity of 1.000, no allowance to be made for contraction?

20.—How many grams of ferrous iodide in 750 mils of syrup of ferrous iodide (Sp. Gr. 1.35) if 4.2% of iodine is used in its manufacture?

21.—If 42 grams of iodine are used in the manufacture of 1000 grams of syrup of ferrous iodide, what will be the percentage of ferrous iodide in the syrup?

22.—How many grains of mercuric chloride must be dissolved in a pint of water, so that when one fluidram of the solution is added to a quart of water the strength shall be 1 to 1000?

85.—PROBLEMS BASED ON THE TABLES OF THE PHARMACOPŒIA

Many of the problems of this section may be solved independently. If this is done the answers should be verified by comparison with those obtained from the tables of the Pharmacopœia. The intention is to encourage the student to become familiar with these valuable tables.

1.—Reduce 600 Gm. to apothecary ounces and grains.

2.—Reduce 500 Gm. to fluidounces and minims.

3.—How many Gm. in 27 fluidounces and 24.5 minims?

4.—How many avoirdupois ounces in 396.893 grams?

5.—How many avoirdupois ounces in 200 grams?

6.—How many milligrams in 50 grains?

7.—How many grains in 0.972 milligrams?

8.—How many minims in 12 mils?

9.—What is the specific volume of a liquid having a specific gravity of 0.920?

10.—What is the volume in liters of a kilogram of a liquid having a specific gravity of 0.75?

11.—What is the avoirdupois weight of 100 fluidounces of a liquid having a specific gravity of 1.16?

12.—What is the volume in gallons of 100 lbs. of a liquid having a specific gravity of 1.000?

13.—How many fluidounces in 1000 grains of liquid having a specific volume of 0.7576?

14.—How many apothecary ounces in 100 fluidounces of a liquid having a specific volume of 0.5435?

15.—How many fluidounces in 100 avoirdupois ounces of a liquid having a specific gravity of 1.84?

16.—How many fluidounces in 10 lbs. of U. S. P. hydrochloric acid?

17.—How many fluidounces in 8 avoirdupois ounces of U. S. P. chloroform?

18.—If a 50-Gm. pycnometer is standardized at 25° C. and is found to hold 52.165 grams of acetic acid, weighed at 20° C., what will be the per cent. of absolute acetic acid?

19.—If a pycnometer holds 25 grams of water at 25° C., and 26.5 grams of acetic acid at 18° C., what will be the percentage strength of the acid?

20.—How many grams of absolute acetic acid in 600 mils of acid having a specific gravity of 1.0350 at 28° C.?

21.—A 100-mil pycnometer, which has been standardized at $\frac{15.6^\circ}{15.6^\circ}$ C., holds at 23° C. 97.1, 93.6, 87.7 and 81.6 grams of diluted alcohols. From the U. S. P. tables determine the percentage by volume, of absolute alcohol in each.

22.—What would be the percentage of absolute alcohol in each if the same weights had been obtained at 25° C.?

TABLES

86.—SATURATION TABLES

Answers to the problems which follow may be obtained from the Saturation Tables. An example may serve to illustrate their use.

A prescription calls for 120 grains of sodium benzoate, which is not in stock. The dispenser turns to Saturation table III, under Sodium Salts, and in the first column, third line, he finds sodium benzoate. By following the line through he finds that it requires 58.32 parts, or grains, of sodium bicarbonate and 84.73 parts, or grains, of benzoic acid to make 100 grains of sodium benzoate. As 120 grains, the required amount, is 1.2 times 100, he takes 1.2 times the above amounts, or 69.98 grains of sodium bicarbonate and 101.67 grains of benzoic acid. If the prescription calls for a liquid all that is necessary is to dissolve the two substances in the liquid and when effervescence ceases it is ready for use. If a dry powder is wanted, the two substances may be moistened with a small quantity of water, and stirred until effervescence ceases, then dry at a low temperature.

PROBLEMS

2.—How many grams each of sodium bicarbonate and dilute acetic acid will be required to make 5 grams of sodium acetate?

3.—How many grains each of salicylic acid and monohydrated sodium carbonate will be required to make 5 drams of sodium salicylate?

4.—How many ounces each of sodium bicarbonate and benzoic acid must be taken to make 10 ounces of sodium benzoate?

5.—In order to make a kilogram of ammonium citrate how many grams of ammonium carbonate and citric acid must be taken?

6.—How many grains of potassium carbonate and diluted hydrobromic acid will be required to make 4 ounces of a solution containing a dram of potassium bromide to the ounce?

7.—If a prescription calls for a dram of ammonium benzoate, which is not in stock, from what can it be made and what quantities must be taken?

8.—How many grams of potassium carbonate will be required to neutralize 25 grams of lactic acid, and what will be the weight of the potassium lactate formed?

9.—How many grains of ammonium carbonate will unite with 5 scruples of hydrochloric acid and what will be the weight of the product?

10.—What will be the weight, in grains, of benzoic acid necessary to neutralize 2 drams of sodium bicarbonate, and how many grains of sodium benzoate will be formed?

SATURATION TABLES

I. Table Showing the Quantity of Official Alkalies Required to Saturate 100 Parts of Official Acid, together with the Quantity of Product.

Acids	Official Per Cent.	Ammonium				Potassium					Sodium				
		Ammon. Carbonate	Ammon. Water 10%	Ammon. Water 28%	Product	Potassium Hydroxide 85%	Sol. of Potassium Hydroxide 5%	Potassium Bicarbonate	Potassium Carbonate	Product	Sodium Hydroxide 90%	Sol. of Sodium Hydroxide 5%	Sodium Bicarbonate	Mono-Hydrat. Sodium Carb.	Product
Acetic	36.0	31.41	102.15	36.48	46.22	39.59	672.98	60.04	41.44	58.84	26.66	479.88	50.38	37.19	81.60
Acetic, diluted	6.0	5.23	17.03	6.08	7.70	6.6	112.16	10.01	6.91	9.81	4.44	79.98	8.40	6.20	13.60
Acetic, glacial	100.0	87.24	283.76	101.34	128.39	109.97	1869.40	166.77	115.11	163.45	74.06	1333.00	139.95	103.30	226.67
Benzoic	100.0	42.91	139.57	49.85	113.95	54.09	919.46	82.02	56.62	175.49	36.42	655.63	68.83	50.81	118.02
Citric	100.0	74.79	243.25	86.88	115.75	94.27	1602.53	143.01	98.68	154.40	63.48	1142.71	119.97	88.55	170.00
Hydrobromic, diluted	10.0	6.47	21.05	7.52	12.10	8.16	138.66	12.37	8.54	14.71	5.49	98.88	10.38	7.66	12.72
Hydrochloric	31.9	45.81	149.00	53.22	46.79	57.74	981.58	87.57	60.44	65.22	38.88	699.93	73.48	54.24	51.13
Hydrochloric, diluted	10.0	14.36	46.71	16.69	14.67	18.10	307.71	27.45	18.95	20.44	12.19	219.41	23.04	17.00	16.03
Lactic	87.5	50.89	165.51	59.11	104.04	64.04	1090.42	97.27	67.14	124.50	43.20	777.54	81.63	60.26	108.87
Nitric	68.0	56.51	183.80	65.64	86.38	71.23	1210.88	108.02	74.56	109.10	47.97	863.43	90.65	66.91	91.73
Nitric, diluted	10.0	8.31	27.03	9.65	12.70	10.47	178.07	15.89	10.97	16.04	7.05	126.98	13.33	9.84	13.49
Phosphoric	86.5	92.42	300.51	107.32	116.54	116.45	1979.72	176.92	121.91	153.70	78.77	1411.79	148.20	109.42	316.09
Phosphoric, diluted	10.0	11.01	34.74	12.41	13.47	13.46	228.88	20.42	14.09	17.77	9.07	163.20	17.13	12.65	36.53
Salicylic	100.0	37.94	123.39	44.07	112.34	47.82	812.89	72.52	50.05	127.59	32.20	579.65	60.86	44.92	115.93
Sulphuric	94.0	100.36	326.41	116.57	126.61	126.49	2150.35	191.83	132.40	166.97	85.18	1533.33	160.98	118.82	308.73
Sulphuric, diluted	10.0	10.68	34.73	12.40	13.47	13.46	228.81	20.41	14.09	17.77	9.06	163.16	17.13	12.64	32.85
Tartaric	.....	69.81	227.04	81.09	122.71	87.99	1495.77	133.44	92.11	156.77	59.25	1066.58	111.98	82.65	153.32
Arsenic trioxide	.....	52.92	172.13	61.48	126.31	66.70	1133.97	101.16	69.83	147.60	44.92	808.61	84.89	62.66	131.33

II. Table Showing the Quantity of Official Acids Required to Saturate 100 Parts of an Official Alkali, together with the Quantity of Product.

Acids

ALKALIES	Official Per Cent.	ACIDS														
		Acetic				Benzoic		Citric		Hydrobromic		Hydrochloric			Lactic	
		36%	6%	100%	Product	100%	Product	100%	Product	100%	Product	31.9%	10%	Product	87.5%	Product
Ammonium carbonate	100.0	318.39	1910.34	114.62	147.16	233.04	265.55	133.71	154.77	1545.25	187.04	218.29	696.35	102.15	196.50	204.46
Ammonia water	10.6	97.89	587.35	35.24	45.25	71.65	81.65	41.11	47.58	475.11	57.51	67.11	214.09	31.41	60.42	62.86
Ammonia water, stronger	28.0	274.10	1644.59	98.68	126.69	200.62	228.62	115.11	133.24	1330.30	161.02	187.92	599.45	87.94	169.16	176.02
Potassium hydroxide	85.0	252.61	1515.64	90.94	148.64	184.89	324.47	106.08	163.79	1225.99	180.30	173.19	552.48	112.95	160.90	194.12
Solution of potassium hydroxide	5.0	14.86	89.16	5.35	8.74	10.88	19.09	6.24	9.64	72.12	10.61	10.19	32.50	6.64	9.17	11.42
Potassium bicarbonate	100.0	166.57	999.40	59.96	98.01	121.92	213.96	69.95	108.00	808.41	118.89	114.20	364.30	74.48	102.80	128.00
Potassium carbonate	100.0	241.32	1447.90	86.87	142.00	176.63	309.97	101.34	156.47	1171.20	172.24	165.45	527.79	107.90	148.94	185.44
Sodium hydroxide	90.0	375.09	2250.56	135.03	306.08	274.54	324.01	157.52	267.78	1820.47	231.51	257.17	820.37	131.50	231.50	252.03
Solution of sodium hydroxide	5.0	20.84	125.03	7.50	17.00	15.25	18.00	8.75	14.88	101.14	12.86	14.29	45.58	7.31	12.86	14.00
Sodium bicarbonate	100.0	198.49	1190.93	71.46	161.97	145.28	171.46	83.40	141.70	963.34	122.51	136.09	434.12	69.59	122.50	133.37
Monohydrated sodium carbonate	100.0	268.91	1613.45	96.81	219.43	196.82	232.29	112.93	191.97	1305.11	165.97	184.37	588.13	94.28	165.98	180.68

II. Continuation of Table Showing the Quantity of Official Acids Required to Saturate 100 Parts of an Official Alkali, together with the Quantity of Product.

Acids

ALKALIES	ACIDS														
	Official Per Cent.	Nitric			Phosphoric			Salicylic		Sulphuric			Tartaric		Arsenic Trioxide	
		68 %	10 %	Product	85 %	10 %	Product	100 %	Product	94 %	10 %	Product	100 %	Product	100 %	Product
Ammonium carbonate	100.0	176.96	1203.29	152.85	108.10	936.16	126.14	263.59	296.11	99.62	936.45	126.16	143.25	175.78	188.95	238.67
Ammonia water	10.0	54.41	369.97	46.99	38.14	287.84	38.79	81.04	91.04	30.63	287.92	38.79	44.04	54.05	58.10	73.38
Ammonia water, stronger	28.0	152.34	1035.91	131.58	93.06	805.94	108.60	226.92	254.92	85.76	806.19	108.61	123.32	151.33	162.67	205.47
Potassium hydroxide	85.0	140.39	954.68	153.72	85.77	742.75	131.98	209.13	266.83	79.03	742.97	132.00	113.65	178.18	149.91	221.26
Solution of potassium hydroxide	5.0	8.26	56.16	9.04	5.04	43.69	7.76	12.30	15.70	4.65	43.70	7.77	6.69	10.48	8.82	13.02
Potassium bicarbonate	100.0	92.58	629.51	101.00	56.55	489.76	87.03	137.90	175.95	52.11	489.91	87.04	74.94	117.49	98.85	145.90
Potassium carbonate	100.0	134.10	911.87	146.32	81.93	709.55	126.09	199.78	254.91	75.50	709.77	126.10	108.58	170.22	143.21	211.38
Sodium hydroxide	90.0	208.47	1417.60	191.23	127.35	1102.90	402.92	310.54	360.00	117.36	1103.24	362.42	168.76	258.75	222.60	292.34
Solution of sodium hydroxide	5.0	11.58	78.76	10.62	7.07	61.27	22.38	17.25	20.00	6.52	61.29	20.13	9.38	14.38	12.37	16.24
Sodium bicarbonate	100.0	110.32	750.15	101.19	67.39	583.62	213.21	164.33	190.50	62.10	583.80	191.78	89.31	136.92	117.80	154.70
Monohydrated sodium carbonate	100.0	149.45	1016.29	137.09	91.30	790.68	288.86	222.65	258.09	84.14	790.92	259.82	120.99	185.50	159.59	209.58

SATURATION TABLES

III. Table Showing the Quantity of Official Alkalies and Acids Required to make 100 Parts of the Corresponding Salts.

(a) Ammonium Salts

AMMONIUM SALTS		Parts of Alkali Required			ACID	
		Ammonium Carbonate 100%	Ammonia Water 10%	Ammonia Water 28%	Parts Required	Official Per Cent.
Ammonium acetate, $NH_4C_2H_3O_2$	= 77.07....	67.96	221.02	78.94	216.36	Acetic acid.......... 36.0
					1298.16	Acetic acid, diluted.......... 6.0
					77.89	Acetic acid, glacial..........100.0
Ammonium arsenite, NH_4AsO_2	= 125.00....	41.90	136.27	48.67	79.17	Arsenic trioxide..........100.0
Ammonium benzoate, $NH_4C_7H_5O_2$	= 139.08....	37.66	122.47	43.74	87.76	Benzoic acid..........100.0
Ammonium bromide, NH_4Br	= 97.96....	53.46	173.88	62.10	826.15	Hydrobromic acid, diluted.......... 10.0
Ammonium chloride, NH_4Cl........	= 53.50....	97.89	318.38	113.71	213.69	Hydrochloric acid.......... 31.9
					681.68	Hydrochloric acid, diluted.......... 10.0
Ammonium citrate, $(NH_4)_3C_6H_5O_7$	= 243.17....	64.61	210.15	75.05	86.39	Citric acid..........100.0
Ammonium lactate, $NH_4C_3H_5O_3$	= 107.08....	48.91	159.07	56.81	112.13	Lactic acid.......... 75.0
					96.11	Lactic acid.......... 87.5
Ammonium nitrate, NH_4NO_3	= 80.05....	65.43	212.79	76.00	115.77	Nitric acid.......... 68.0
					787.26	Nitric acid, diluted.......... 10.0
Ammonium phosphate, $(NH_4)_2HPO_4$	= 132.13....	79.28	257.83	92.08	87.31	Phosphoric acid.......... 85.0
					85.79	Phosphoric acid.......... 86.5
					742.15	Phosphoric acid, diluted.......... 10.0
Ammonium salicylate, $NH_4C_7H_5O_3$	= 155.08....	33.77	109.84	39.23	89.02	Salicylic acid..........100.0
Ammonium sulphate, $(NH_4)_2SO_4$	= 132.15....	79.26	257.80	92.07	80.25	Sulphuric acid.......... 92.5
					78.96	Sulphuric acid.......... 94.0
					742.26	Sulphuric acid, diluted.......... 10.0
Ammonium tartrate, $(NH_4)_2C_4H_4O_6$	= 184.12....	56.89	185.03	66.08	81.50	Tartaric acid..........100.0

SATURATION TABLES

III. Continuation of Table Showing the Quantity of Official Alkalies and Acids Required to make 100 Parts of the Corresponding Salts.

(b) Potassium Salts

POTASSIUM SALTS		Parts of Alkali Required				ACID	
		Potassium Hydroxide 85%	Sol. of Potassium Hydroxide 5%	Potassium Bicarbonate 100%	Potassium Carbonate 100%	Parts Required	Official Per Cent.
Potassium acetate, $KC_2H_3O_2$	= 98.12	67.28	1143.70	102.03	70.42	169.95	Acetic acid 36.0
						1019.67	Acetic acid, diluted 6.0
						61.18	Acetic acid, glacial 100.0
Potassium arsenite, $KAsO_2$	= 146.06	45.19	768.31	68.54	47.31	67.75	Arsenic trioxide. 100.0
Potassium benzoate, $KC_7H_5O_2 + H_2O$	= 214.19	30.82	523.93	46.74	32.26	56.98	Benzoic acid 100.0
Potassium bromide, KBr	= 119.02	55.46	942.87	84.11	58.06	679.97	Hydrobromic acid, diluted . . 10.0
Potassium chloride, KCl	= 74.56	88.54	1505.10	134.27	92.68	153.34	Hydrochloric acid 31.9
						489.14	Hydrochloric acid, diluted . . 10.0
Potassium citrate, $K_3C_6H_5O_7 + H_2O$	= 324.36	61.05	1037.92	92.59	63.91	64.77	Citric acid 100.0
Potassium lactate, $KC_3H_5O_3$	= 128.14	51.52	875.76	78.13	53.93	80.31	Lactic acid 87.5
Potassium nitrate, KNO_3	= 101.11	65.29	1109.88	99.01	68.34	91.66	Nitric acid 68.0
						623.28	Nitric acid, diluted 10.0
Potassium phosphate, K_2HPO_4	= 174.25	75.77	1288.03	114.91	79.31	64.98	Phosphoric acid. 86.5
						562.76	Phosphoric acid, diluted 10.0
Potassium salicylate, $KC_7H_5O_3$	= 176.14	37.48	637.11	56.83	39.23	78.38	Salicylic acid 100.0
Potassium sulphate, K_2SO_4	= 174.27	75.76	1287.89	114.89	79.30	59.87	Sulphuric acid 94.0
						562.86	Sulphuric acid, diluted. 10.0
Potassium tartrate, $2K_2C_4H_4O_6 + H_2O$	= 470.48	56.12	954.09	85.11	58.75	63.79	Tartaric acid 100.0

SATURATION TABLES

III. Continuation of Table Showing the Quantity of Official Alkalies and Acids Required to make 100 Parts of the Corresponding Salts.

(c) Sodium Salts

SODIUM SALTS	Parts of Alkalies Required				ACID	
	Sodium Hydroxide 90%	Sol. of Sodium Hydroxide 5%	Sodium Bicarbonate 100%	Monohydrated Sodium Carb. 100%	Parts Required	Official Per Cent.
Sodium acetate, $NaC_2H_3O_2 + 3H_2O$ = 136.07	32.67	588.08	61.74	45.57	122.55	Acetic acid 36.0
					735.28	Acetic acid, diluted 6.0
					44.12	Acetic acid, glacial 100.0
Sodium arsenite, $NaAsO_2$ = 129.96	34.21	615.73	64.64	47.72	76.15	Arsenic trioxide 100.0
Sodium benzoate, $NaC_7H_5O_2$ = 144.04	30.86	555.54	58.32	43.05	84.73	Benzoic acid 100.0
Sodium bromide, NaBr = 102.92	43.19	777.50	81.63	60.25	786.34	Hydrobromic acid, diluted .. 10.0
Sodium chloride, NaCl = 58.46	76.04	1368.80	143.71	106.07	195.55	Hydrochloric acid 31.9
					623.85	Hydrochloric acid, diluted .. 10.0
Sodium citrate, $2Na_3C_6H_5O_7 + 11H_2O$ = 714.26	37.34	672.19	70.57	52.09	58.83	Citric acid 100.0
Sodium lactate, $NaC_3H_5O_3$ = 112.04	39.68	714.21	74.98	55.35	91.84	Lactic acid 87.5
Sodium nitrate, $NaNO_3$ = 85.01	52.30	941.30	98.82	72.94	109.02	Nitric acid 68.0
					741.33	Nitric acid, diluted 10.0
Sodium phosphate, $Na_2HPO_4 + 12H_2O$ = 358.24	24.82	446.74	46.90	34.62	31.60	Phosphoric acid 86.5
					273.73	Phosphoric acid, diluted 10.0
Sodium salicylate, $NaC_7H_5O_3$ = 160.04	27.76	500.00	52.49	38.75	86.26	Salicylic acid 100.0
Sodium sulphate, $Na_2SO_4 + 10H_2O$ = 322.23	27.59	496.66	52.14	38.49	31.67	Sulphuric acid 94.0
					304.41	Sulphuric acid, diluted 10.0
Sodium tartrate, $Na_2C_7H_4O_6 + 2H_2O$ = 230.06	38.65	695.65	73.03	53.91	65.22	Tartaric acid 100.0

CONVERSION TABLES

The following tables, by Dr. A. B. Lyons, will be found especially valuable for converting the strengths of preparations from one system of weights and measures to those of another. Example: We desire to know the strength, in the metric system, of a preparation that contains 120 grains in a fluidounce. Under grains per fluidounce, we find 20 and opposite under gram per liter we find 43.9; also opposite 100 we find 219.5; $43.9 + 219.5 = 263.4$, the number of grams in a liter that are equal to 120 grains in a fluidounce.

GRAINS PER FLUIDOUNCE EQUIVALENT TO GRAMS PER LITER

Grains per Fluid Oz.	Grams per Liter.	Grains per Fluid Oz.	Grams per Liter	Grains per Fluid Oz.	Grams per Liter
1	2.2	9	19.8	80	175.6
2	4.4	10	22.0	90	197.5
3	6.6	20	43.9	100	219.5
4	8.8	30	65.9	200	439.0
5	11.0	40	87.8	300	658.5
6	13.2	50	109.8	400	878.0
7	15.4	60	131.7	500	1097.5
8	17.6	70	153.6	600	1316.9

GRAINS PER FLUIDRAM EQUIVALENT TO GRAMS PER LITER

Grains per Fluid Dr.	Grams per Liter	Grains per Fluid Dr.	Grams per Liter	Grains per Fluid Dr.	Grams per Liter
1	17.6	7	122.9	40	702.4
2	35.1	8	140.5	50	878.0
3	52.7	9	158.0	60	1053.6
4	70.2	10	175.6	70	1229.1
5	87.8	20	351.2	80	1404.7
6	105.4	30	526.8		

MINIMS PER FLUIDOUNCE EQUIVALENT TO MILS PER LITER

Minims per Fluid Oz.	Mils per Liter	Minims per Fluid Oz.	Mils per Liter	Minims per Fluid Oz.	Mils per Liter
1	2.1	9	18.8	80	166.7
2	4.2	10	20.8	90	187.5
3	6.3	20	41.7	100	208.3
4	8.3	30	62.5	200	416.7
5	10.4	40	83.3	300	625.0
6	12.5	50	105.2	400	833.3
7	14.6	60	125.0	480	1000.0
8	16.7	70	145.8		

MINIMS PER FLUIDRAM EQUIVALENT TO MILS PER LITER

Minims per Fluid Dr.	Mils per Liter	Minims per Fluid Dr.	Mils per Liter	Minims per Fluid Dr.	Mils per Liter
1	16.7	6	100.0	20	333.3
2	33.3	7	116.7	30	500.0
3	50.0	8	133.3	40	666.7
4	66.7	9	150.0	50	833.3
5	83.3	10	166.7	60	1000.0

MILS PER LITER, EQUIVALENT TO MINIMS, ETC., PER GALLON

Mils per Liter	Minims, Etc., per Gallon			Minims, Etc., per Pint		Minims per Fl. Oz.	Minims per Fl. Drm.
	Lb.	Fl. Oz.	Min.	Fl. Oz.	Min.	Minims	Minims
1	..	..	61.4	..	7.7	0.5	0.06
2	..	..	122.9	..	15.4	1.0	0.12
3	..	..	184.3	..	23.0	1.4	0.18
4	..	..	245.8	..	30.7	1.9	0.24
5	..	..	307.2	..	38.4	2.4	0.30
6	..	..	368.6	..	46.1	2.9	0.36
7	..	..	430.1	..	53.8	3.4	0.42
8	..	1	11.5	..	61.4	3.8	0.48
9	..	1	73.0	..	69.1	4.3	0.54
10	..	1	134	..	76.8	4.8	0.6
20	..	2	269	..	153.6	9.6	1.2
30	..	3	403	..	230.4	14.4	1.8
40	..	5	58	..	307.2	19.2	2.4
50	..	6	192	..	384.0	24.0	3.0
60	..	7	326	..	460.8	28.8	3.6
70	..	8	461	1	57.6	33.6	4.2
80	..	10	115	1	134.4	38.4	4.8
90	..	11	250	1	211.2	43.2	5.4
100	..	12	384	1	288	48	6
200	1	9	288	3	96	96	12
300	2	6	192	4	384	144	18
400	3	3	96	6	192	192	24
500	4	0	0	8	0	240	30
600	4	12	384	9	288	288	36
700	5	9	288	11	96	336	42
800	6	6	192	12	384	384	48
900	7	3	96	14	192	432	54
1000	8	0	0	16	0	480	60

GRAMS PER LITER, EQUIVALENT TO GRAINS, ETC., PER GALLON

Grams per Liter	Grains, Etc., per Gallon			Grains, Etc., per Pint		Grains per Fl. Oz.	Grains per Fl. Drm.
	Lb.	Oz.	Gr.	Oz.	Gr.	Gr.	Gr.
1	. .	. .	58.3	. .	7.3	0.5	0.06
2	. .	. .	116.6	. .	14.6	0.9	0.11
3	. .	. .	175.0	. .	21.9	1.4	0.17
4	. .	. .	233.3	. .	29.2	1.8	0.23
5	. .	. .	291.6	. .	36.5	2.3	0.29
6	. .	. .	349.9	. .	43.7	2.7	0.34
7	. .	. .	408.2	. .	51.0	3.2	0.40
8	. .	1	29.1	. .	58.3	3.6	0.46
9	. .	1	87.4	. .	65.6	4.1	0.51
10	. .	1	146	. .	72.9	4.6	0.57
20	. .	2	291	. .	145.8	9.1	1.14
30	. .	3	437	. .	218.7	13.7	1.71
40	. .	5	145	. .	291.6	18.2	2.28
50	. .	6	291	. .	364.5	22.8	2.85
60	. .	7	437	. .	437.4	27.3	3.42
70	. .	9	145	1	72.8	31.9	3.99
80	. .	10	291	1	145.7	36.5	4.56
90	. .	11	436	1	218.6	41.0	5.13
100	. .	13	145	1	292	45.6	5.7
200	1	10	289	3	146	91.1	11.4
300	2	7	434	4	437	136.7	17.1
400	3	5	141	6	291	182.2	22.8
500	4	2	285	8	145	227.8	28.5
600	4	15	430	9	437	273.4	34.2
700	5	13	137	11	290	318.9	39.9
800	6	10	181	13	145	364.5	45.6
900	7	7	426	14	436	410.0	51.3
1000	8	5	133	16	290	455.6	57.0

Tables giving the quantities by weight or measure required to make one gallon of a mixture, each fluidram of which is to contain a given dose. The same table may be used to make one pint by dividing the quantity by eight.

Dose in Grains	Quantity per Gallon		Dose in Grains	Quantity per Gallon			Dose in Minims	Quantity per Gallon		
	Oz.	Grains		Lb.	Oz.	Grains		Pts.	Fl.Oz.	Min.
1/1000	..	1.02	0.01	..	..	10.24	1/8	..	..	128
1/500	..	2.05	0.02	..	..	20.48	1/4	..	..	256
1/400	..	2.56	0.03	..	..	30.72	1/3	..	..	341.3
1/350	..	2.93	0.04	..	..	40.96	3/8	..	..	384
1/333	..	3.07	0.05	..	..	51.20	1/2	..	1	32
1/320	..	3.20	0.06	..	..	61.44	5/8	..	1	160
1/300	..	3.41	0.07	..	..	71.68	2/3	..	1	202.6
1/250	..	4.10	0.08	..	..	81.92	3/4	..	1	288
1/240	..	4.27	0.09	..	..	92.16	7/8	..	1	416
1/200	..	5.12	0.1	..	..	102.4	1	..	2	64
1/160	..	6.40	0.2	..	..	204.8	2	..	4	128
1/150	..	6.83	0.3	..	..	307.2	3	..	6	192
1/128	..	8	0.4	..	..	409.6	4	..	8	256
1/100	..	10.24	0.5	..	1	74.5	5	..	10	320
1/90	..	11.38	0.6	..	1	176.9	6	..	12	384
1/80	..	12.8	0.7	..	1	279.3	7	..	14	448
1/75	..	13.65	0.8	..	1	281.7	8	1	1	32
1/70	..	14.63	0.9	..	2	46.6	9	1	2	96
1/65	..	15.75	1	..	2	149.0	10	1	5	160
1/64	..	16	2	..	4	298.0	20	2	10	320
1/60	..	17.07	3	..	7	9.5	30	4	0	0
1/55	..	18.62	4	..	9	158.5	40	5	5	160
1/50	..	20.48	5	..	11	307.5	50	6	10	320
1/48	..	21.33	6	..	14	19.0	60	8	0	0
1/45	..	22.76	7	1	0	168.0	....	..	..	....
1/40	..	25.60	8	1	2	317.0	....	..	..	....
1/35	..	29.26	9	1	5	128.5	....	..	..	....
1/32	..	32	10	1	7	117.5	....	..	..	....
1/30	..	34.13	20	2	14	355	....	..	..	....
1/25	..	41	30	4	6	95	....	..	..	....
1/24	..	42.67	40	5	13	273	....	..	..	....
1/20	..	51.2	50	7	5	13	....	..	..	....
1/18	..	56.89	60	8	12	190	....	..	..	....
1/16	..	64	70	10	3	368	....	..	..	....
1/15	..	68.27	80	11	11	109	....	..	..	....
1/12	..	85.33	90	13	2	285	....	..	..	....
1/10	..	102.4	100	14	10	25	....	..	..	....
1/8	..	128	....	..	..	.....	....	..	..	....
1/6	..	170.6	....	..	..	.....	....	..	..	....
1/5	..	204.8	....	..	..	.....	....	..	..	....
1/4	..	256	....	..	..	.....	....	..	..	....
1/3	..	341.3	....	..	..	.....	....	..	..	....
3/8	..	384	....	..	..	.....	....	..	..	....
1/2	1	74.5	....	..	..	.....	....	..	..	....
5/8	1	202.5	....	..	..	.....	....	..	..	....
2/3	1	245.2	....	..	..	.....	....	..	..	....
3/4	1	330.5	....	..	..	.....	....	..	..	....
7/8	2	21	....	..	..	.....	....	..	..	....

International Atomic Weights for 1918

(From "Journal of the American Chemical Society," Vol. 39, page 2517)

		O=16
Aluminum	Al	27.1
Antimony	Sb	120.2
Argon	A	39.88
Arsenic	As	74.96
Barium	Ba	137.37
Bismuth	Bi	208.0
Boron	B	11.0
Bromine	Br	79.92
Cadmium	Cd	112.40
Cæsium	Cs	132.81
Calcium	Ca	40.07
Carbon	C	12.00
Cerium	Ce	140.25
Chlorine	Cl	35.46
Chromium	Cr	52.0
Cobalt	Co	58.97
Columbium	Cb	93.1
Copper	Cu	63.57
Dysprosium	Dy	162.5
Erbium	Er	167.7
Europium	Eu	152.0
Fluorine	F	19.0
Gadolinium	Gd	157.3
Gallium	Ga	69.9
Germanium	Ge	72.5
Glucinum	Gl	9.1
Gold	Au	197.2
Helium	He	4.00
Holmium	Ho	163.5
Hydrogen	H	1.008
Indium	In	114.8
Iodine	I	126.92
Iridium	Ir	193.1
Iron	Fe	55.84
Krypton	Kr	82.92
Lanthanum	La	139.0
Lead	Pb	207.20
Lithium	Li	6.94
Lutecium	Lu	175.0
Magnesium	Mg	24.32
Manganese	Mn	54.93
Mercury	Hg	200.6
Molybdenum	Mo	96.0

		O=16
Neodymium	Nd	144.3
Neon	Ne	20.2
Nickel	Ni	58.68
Niton (radium emanation)	Nt	222.4
Nitrogen	N	14.01
Osmium	Os	190.9
Oxygen	O	16.00
Palladium	Pd	106.7
Phosphorus	P	31.04
Platinum	Pt	195.2
Potassium	K	39.10
Praseodymium	Pr	140.9
Radium	Ra	226.0
Rhodium	Rh	102.9
Rubidium	Rb	85.45
Ruthenium	Ru	101.7
Samarium	Sa	150.4
Scandium	Sc	44.1
Selenium	Se	79.2
Silicon	Si	28.3
Silver	Ag	107.88
Sodium	Na	23.00
Strontium	Sr	87.63
Sulfur	S	32.06
Tantalum	Ta	181.5
Tellurium	Te	127.5
Terbium	Tb	159.2
Thallium	Tl	204.0
Thorium	Th	232.4
Thulium	Tm	168.5
Tin	Sn	118.7
Titanium	Ti	48.1
Tungsten	W	184.0
Uranium	U	238.2
Vanadium	V	51.0
Xenon	Xe	130.2
Ytterbium (Neoytterbium)	Yb	173.5
Yttrium	Yt	88.7
Zinc	Zn	65.37
Zirconium	Zr	90.6

List of Chemicals used in this Book, together with formulas and Molecular Weights.

Acid Acetic	$HC_2H_3O_2$	60.03
Acid Benzoic	$HC_7H_5O_2$	122.05
Acid Boric	H_3BO_3	62.02
Acid Citric	$H_3C_6H_5O_7.H_2O$	210.08
Acid Citric, dry	$H_3C_6H_5O_7$	192.06
Acid Hydriodic	HI	127.93
Acid Hydrobromic	HBr	80.93
Acid Hydrochloric	HCl	36.47
Acid Hydrocyanic	HCN	27.02
Acid Nitric	HNO_3	63.02
Acid Nitrous	HNO_2	47.02
Acid Oxalic	$H_2C_2O_4.2H_2O$	126.05
Acid Oxalic, dry	$H_2C_2O_4$	90.02
Acid Phosphoric	H_3PO_4	98.06
Acid Salicylic	$HC_7H_5O_3$	138.05
Acid Sulphuric	H_2SO_4	98.09
Acid Sulphurous	H_2SO_3	82.09
Acid Tartaric	$H_2C_4H_4O_6$	150.05
Alcohol, ethyl	C_2H_5OH	46.05
Aluminum Hydroxide	$Al(OH)_3$	78.12
Ammonia	NH_3	17.034
Ammonium Carbonate (normal)	$(NH_4)_2CO_3$	96.08
Ammonium Carbonate (U. S. P.)	$NH_4HCO_3.NH_4NH_2CO_2$	157.12
Ammonium Chloride	NH_4Cl	53.50
Ammonium Citrate	$(NH_4)_3C_6H_5O_7$	243.17
Arsenic Sulphide	As_2S_5	310.27
Arsenic Trioxide	As_2O_3	197.92
Arsine	AsH_3	77.98
Barium Carbonate	$BaCO_3$	197.37
Barium Chloride	$BaCl_2.2H_2O$	244.32
Barium Chloride, dry	$BaCl_2$	208.29
Barium Sulphate	$BaSO_4$	233.44
Calcium Carbonate	$CaCO_3$	100.07
Calcium Chloride	$CaCl_2.6H_2O$	219.09
Calcium Chloride	$CaCl_2.2H_2O$	147.02
Calcium Chloride, dry	$CaCl_2$	110.99
Calcium Oxide	CaO	56.07
Carbon Dioxide	CO_2	44.0
Carbon Trioxide	CO_3	60.0
Cocaine	$C_{17}H_{21}NO_4$	303.18
Cupric Sulphate	$CuSO_4.5H_2O$	249.72

Cupric Sulphate, dry	$CuSO_4$	159.64
Ethyl Nitrite	$C_2H_5NO_2$	75.05
Ethyl Oxide (Ether)	$(C_2H_5)_2O$	74.08
Ferric Chloride	$FeCl_36H_2O$	270.32
Ferric Chloride, dry	$FeCl_3$	162.22
Ferric Oxide	Fe_2O_3	159.68
Ferric Sulphate	$Fe_2(SO_4)_3$	399.89
Ferrous Bromide, dry	$FeBr_2$	215.68
Ferrous Bromide	$FeBr_2.6H_2O$	323.78
Ferrous Carbonate	$FeCO_3$	115.84
Ferrous Iodide	FeI_2	309.68
Ferrous Sulphate	$FeSO_4.7H_2O$	278.02
Ferrous Sulphate, dry	$FeSO_4$	151.91
Hydrogen Dioxide	H_2O_2	34.02
Hydrogen Sulphide	H_2S	34.09
Lead Acetate	$Pb(C_2H_3O_2)_2.3H_2O$	379.20
Lead Acetate, dry	$Pb(C_2H_3O_2)_2$	325.15
Lead Chloride	$PbCl_2$	278.02
Lead Iodide	PbI_2	460.94
Lead Oxide	PbO	223.10
Lead Sulphate	$PbSO_4$	303.26
Lead Sulphide	PbS	239.26
Lithium Carbonate	Li_2CO_3	73.88
Magnesium Carbonate (approx.)	$(MgCO_3)_4Mg(OH)_2.5H_2O$	485.70
Magnesium Oxide	MgO	40.32
Magnesium Sulphate	$MgSO_4.7H_2O$	246.50
Magnesium Sulphate, dry	$MgSO_4$	120.39
Mercuric Chloride	$HgCl_2$	271.52
Mercuric Oxide	HgO	216.60
Mercurous Chloride	$HgCl$	236.06
Methane	CH_4	16.032
Morphine	$C_{17}H_{19}NO_3.H_2O$	303.18
Morphine, dry	$C_{17}H_{19}NO_3$	285.16
Nitrogen Dioxide	NO_2	46.01
Nitric Oxide	NO	30.01
Nitrous Oxide	N_2O	44.02
Ozone	O_3	48.00
Paraldehyde	$C_6H_{12}O_3$	132.10
Phosphine	PH_3	34.06
Potassium Bicarbonate	$KHCO_3$	100.11
Potassium Bromide	KBr	119.02
Potassium Carbonate	K_2CO_3	138.20
Potassium Chlorate	$KClO_3$	122.56
Potassium Chloride	KCl	74.56

Potassium Citrate	$K_3C_6H_5O_7.H_2O$	324.36
Potassium Citrate, Dry	$K_3C_6H_5O_7$	306.34
Potassium Cyanide	KCN	65.11
Potassium Hydroxide	KOH	56.11
Potassium Hypophosphite	KPH_2O_2	104.16
Potassium Iodide	KI	166.02
Potassium Permanganate	$KMnO_4$	158.03
Potassium Phosphate	K_2HPO_4	174.25
Potassium Sulphocyanide	$KSCN$	97.18
Silver Chloride	$AgCl$	143.34
Silver Cyanide	$AgCN$	133.89
Silver Iodide	AgI	234.80
Silver Nitrate	$AgNO_3$	169.89
Sodium Bicarbonate	$NaHCO_3$	84.01
Sodium Carbonate	$Na_2CO_3.10H_2O$	286.16
Sodium Carbonate, Monohydrated	$Na_2CO_3.H_2O$	124.02
Sodium Carbonate, dry	Na_2CO_3	106.00
Sodium Chloride	$NaCl$	58.46
Sodium Hydroxide	$NaOH$	40.01
Sodium Hyposulphite (Thiosulphate)	$Na_2S_2O_3.5H_2O$	248.22
Sodium Iodide	NaI	149.92
Sodium Nitrate	$NaNO_3$	85.01
Sodium Nitrite	$NaNO_2$	69.01
Sodium Phosphate	$Na_2HPO_4.12H_2O$	358.24
Sodium Phosphate, dry	Na_2HPO_4	142.05
Sodium Salicylate	$NaC_7H_5O_3$	160.04
Sodium Sulphate	$Na_2SO_4.10H_2O$	322.23
Sodium Sulphate, dry	Na_2SO_4	142.07
Sodium Sulphite	$Na_2SO_3.7H_2O$	252.18
Sodium Sulphite, dry	Na_2SO_3	126.07
Sulphur Dioxide	SO_2	64.07
Sulphuric Anhydride	SO_3	80.07
Water	H_2O	18.016
Zinc Chloride	$ZnCl_2$	136.29
Zinc Sulphate	$ZnSO_4.7H_2O$	287.55
Zinc Sulphate, dry	$ZnSO_4$	161.44

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